

TECHNICAL JUSTIFICATION OF EQUIVALENCY
FOR SURFACE IMPOUNDMENT REQUIREMENTS
FOR THE TEMPORARY STORAGE AREA
BASIN AND SITE WATER TREATMENT
PLANT EQUALIZATION BASIN

MAY, 1991

Technical Justification of Equivalency for Surface Impoundment Requirements

As a part of the overall cleanup of the Weldon Spring quarry and Weldon Spring chemical plant, the DOE is planning to construct a lined basin for storage of leachate and runoff water at the Temporary Storage Area (TSA), and also a lined equalization basin for the site water treatment plant (SWTP).

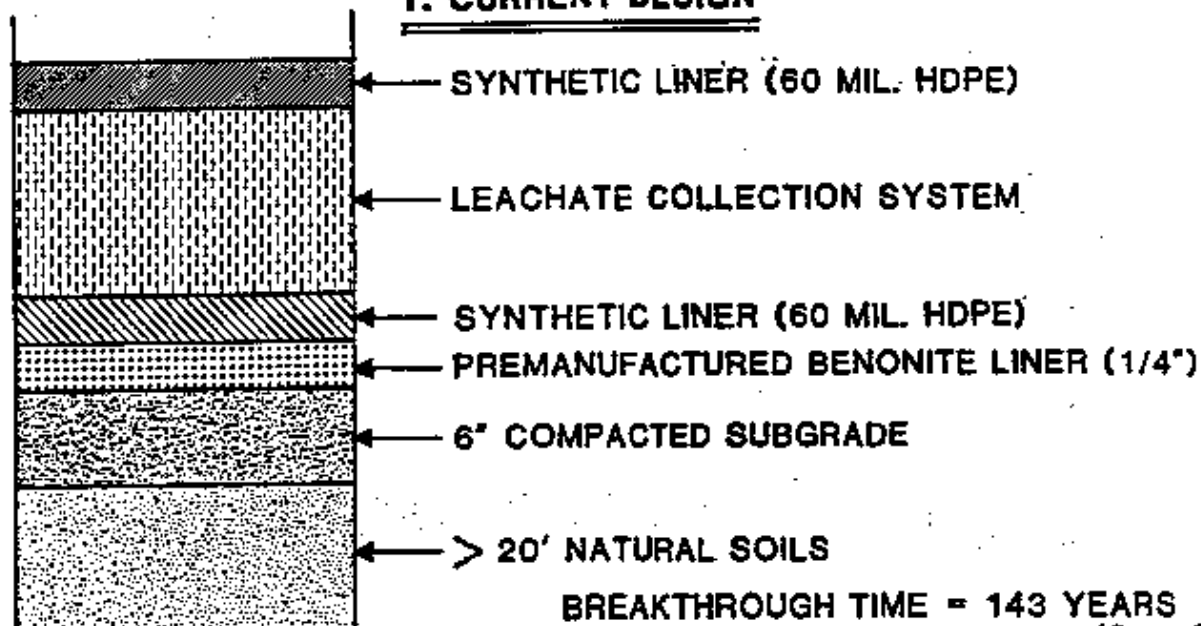
The current design of these facilities includes from top to bottom, a 60 mil HDPE synthetic liner, a leachate collection system, a secondary 60 mil HDPE synthetic membrane, and a 1/4-inch bentonite liner composite underlain by 6 inches of compacted subgrade. A conceptual diagram of this configuration is shown in Figure 1.

The state of Missouri RCRA requirements (Ref. 5), include a synthetic liner and a leachate collection system underlain by 3 feet of 1×10^{-8} cm/sec clay layer. The 3 feet of 1×10^{-8} cm/sec clay can not be met with the existing soils at the TSA or the SWTP, but the proposed system exceeds the state requirements due to the extremely low permeability of the added premanufactured composite liner.

The operational life of these facilities is expected to be 10 years. Synthetic composite liners are a preferable low permeability barrier to clay for short term durations (i.e. less than 30 years). The following reasons are in support of the current design for the two impoundments.

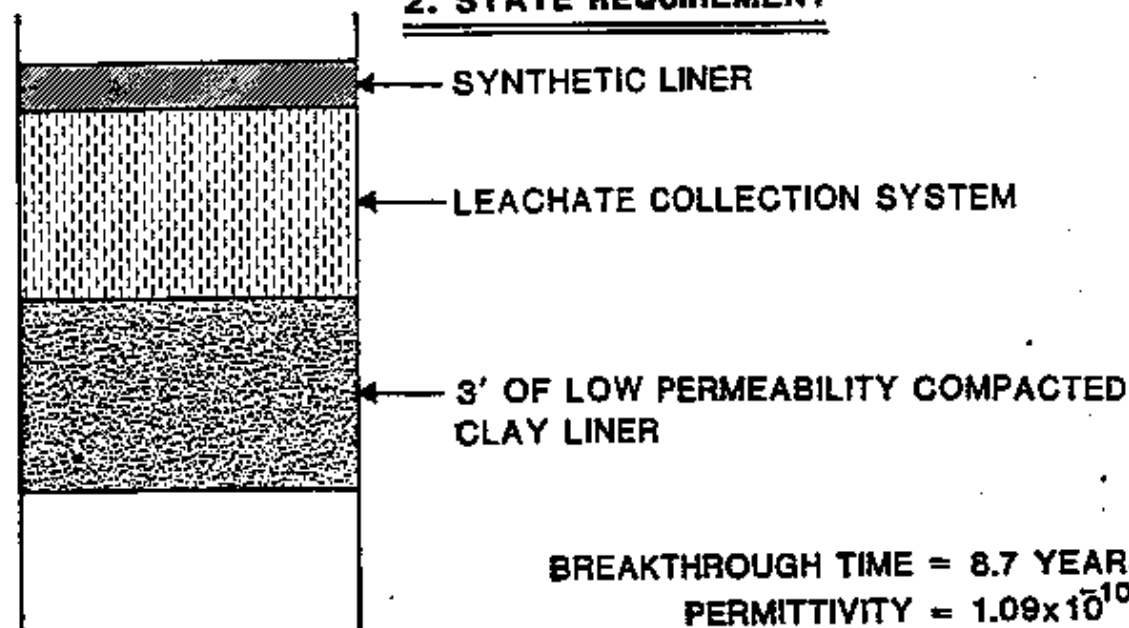
1. Clay materials resulting from planned excavations within TSA and site water treatment plant areas cannot achieve low enough permeabilities (i.e. 1×10^{-8} cm/sec), even with extensive compaction (Appendixes A and C). The average hydraulic conductivity deducted from laboratory tests performed on four remolded samples obtained from the TSA area was only 1.33×10^{-7} cm/sec, compared with an average of less than 3×10^{-9} cm/sec resulting from samples obtained from the same soil unit in the northwest portion of the site (Appendixes A and B).
2. Since the performance period of the proposed units is low, the thickness of the low permeability soil liner is not as important as the overall low permeability of the system used in the current design. Assuming the primary synthetic liner and the leachate collection system fail, then the state

1. CURRENT DESIGN



BREAKTHROUGH TIME = 143 YEARS
PERMITTIVITY = $6.6 \times 10^{-12} \text{ SEC}^{-1}$

2. STATE REQUIREMENT



BREAKTHROUGH TIME = 8.7 YEARS
PERMITTIVITY = $1.09 \times 10^{-10} \text{ SEC}^{-1}$

CONCEPTUAL DIAGRAM

FIGURE 1

NOT TO SCALE

REPORT NO.:		EXHIBIT NO.:	
		A/PI/086/0591	
ORIGINATOR	SDG	DRAWN BY:	GLN
		DATE	5/91

requirement is intended to provide long term protection with 3 ft of low permeability clay. The current design is intended to provide a second line of defense against any leakage from the basins with the secondary composite liner, and mid-long term protection provided by the bentonite composite, the 6 inches of compacted subgrade and the more than 20 ft of in situ soil material.

3. An added practical benefit of the current design is the close contact between the lower synthetic liner and the bentonite layer. The bentonite layer adheres to the synthetic liner, so that any compromise in the synthetic liner will be sealed with the bentonite material.

In order to compare the current design with the state requirements, calculations were performed to compare the permittivities of the two systems. The permittivity is defined as the ratio between the hydraulic conductivity and thickness, and is measured in Sec^{-1} . (Ref. 4) This parameter defines the capability of a system to reduce and retard infiltration.

Using this parameter and the effective porosity of a layer, the breakthrough time can be roughly estimated. The calculated effective porosity for a low permeability clay liner is 0.07 to 0.08 (Appendix A). For conservative purposes, a value of 0.03 for the effective porosity was selected for both systems. The average hydraulic conductivity for each system is calculated using the following relation, according to Todd (Ref. 2).

$$K_{AV} = \frac{Z_1 + Z_2 + \dots + Z_n}{\frac{Z_1}{K_1} + \frac{Z_2}{K_2} + \dots + \frac{Z_n}{K_n}}$$

where K_i and Z_i are permeabilities and thicknesses for each layer.

The permittivity is

$$T = \frac{K_{AV}}{Z_1 + Z_2 + \dots + Z_n}$$

and the breakthrough time is

$$t = \frac{e}{T} = \frac{(Z_1 + Z_2 + \dots + Z_n) e}{K_{AV}}$$

where e is the effective porosity.

Option 1. (Current Design)

Synthetic Liner

Leachate Collection

Synthetic Liner - 60 mil (0.15 cm), $K_1 = 1 \times 10^{-12}$ cm/sec (Ref. 3)

Bentonite Composite - 1/4" (0.63 cm), $K_2 = 1 \times 10^{-9}$ cm/sec (Ref. 3)

Compacted Subgrade - 6"

Natural Soil - 20'

Note: The upper HDPE synthetic liner is not considered in calculations.

The average permeability is:

$$K_{AV} = \frac{0.15 + 0.63}{\frac{0.15}{1 \times 10^{-12}} + \frac{0.63}{1 \times 10^{-9}}} = 5.17 \times 10^{-12} \text{ cm/sec.}$$

Permittivity

$$T = \frac{5.17 \times 10^{-12}}{(0.15 + 0.63)} = 6.6 \times 10^{-12} \text{ sec}^{-1}$$

Breakthrough time to compacted subgrade:

$$t = \frac{0.03}{6.6 \times 10^{-12}} = 4.52 \times 10^9 \text{ sec} = 143 \text{ years.}$$

Option 2 (State Requirements)

Synthetic liner

Leachate collection

Compacted clay - 3' (91.5 cm) with $K = 1 \times 10^{-8} \text{ cm/sec}$

Note: The upper HDPE synthetic liner is not included in calculations.

Permittivity:

$$T = \frac{1 \times 10^{-8}}{91.5} = 1.09 \times 10^{-10} \text{ sec}^{-1}$$

Breakthrough time through the compacted clay liner:

$$t = \frac{0.03}{1.09 \times 10^{-10}} = 2.74 \times 10^8 \text{ sec} = 8.7 \text{ years}$$

In conclusion, the permittivity of the current design is two orders of magnitude lower than that calculated considering state requirements. Also, the estimated breakthrough time is increased from approximately nine years to more than one hundred years.

APPENDIX A



SUMMARY OF CALCULATION RESULTS

Seven boreholes, GTS-1 through GTS-7 were drilled in May-June 1989 in the Temporary Storage Area. Locations of these boreholes are shown on figure 2-1. Borehole logs are presented in Appendix B. In addition, two boreholes GT-73 and GT-74 were drilled in April 1991 within the Site Water Treatment Plant area. Field logs of these boreholes are also attached in Appendix B.

Laboratory test results on samples taken from borings GTS-1 through GTS-7 are shown in Appendix A. A summary of these results is presented in table 2-1. Although laboratory test results on samples from GT-73 and GT-74 are not yet available, the lithologic logs of these boreholes show materials very similar to those identified in GTS-1 through GTS-7.

Average values of geotechnical parameters for representative samples from GTS-1 through GTS-7 are shown in table 2-2. A logarithmic mean was used to obtain the average permeability for these samples.



Performing the same calculations for a soil compacted at +4% wet of optimum moisture leads to:

$$P_d = 95\% \times 103.9 = 98.7\% \text{ wet}$$

$$e = \frac{2.71 \times 62.4}{98.7} = 0.713$$

$$S = \frac{21.95 \times 2.71 \times 98.7}{2.71 \times 62.4 - 98.7} = 83.5\%$$

$$\alpha = \frac{0.713}{1.713} = 0.416$$

$$u = 0.416 \times (1 - 0.835) = 0.069$$

Selecting a value of 0.03 for the effective porosity, the results are on the conservative side.

Also, for conservative reasons, the same value of 0.03 was used for the bentonite layer.

Hydraulic conductivities for the HDPE and bentonite layers were selected on the conservative side. For the HDPE a value of 1×10^{-12} cm/sec was used in calculations. For the bentonite layer, the hydraulic conductivity was selected 1×10^{-9} cm/sec (Ref 4, 5).

TABLE 2-1.

10000
3000-10000

SUMMARY OF SOIL TEST RESULTS
(Sheet 6 of 10)

110000

Soil or Trench Number	Sample Number	Depth (ft)		Laboratory Classification	Disturbed Analysis (lb)			Shrinkage Limit (%)	Specific Gravity G	Natural		Vib. Proctor Compaction (ASTM D1557)		Relative Density		Consolidation			Soil Unit
		From	To		Unconf.	Comp.	Flow			W (%)	d ₁₀ (mm)	q (lb)	q _u (lb)	q _u (lb)	q _u (lb)	e _s	e _p	e _u	
010-1	01-01	3.0	3.5	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1
010-2	01-02	2.5	3.0							18.2	0.25	10.5	102.4	102.4	102.4				1
010-3	01-03	2.5	3.0	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1
010-4	01-04	2.5	3.0	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1
010-5	01-05	2.5	3.0	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1
010-6	01-06	2.5	3.0	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1
010-7	01-07	2.5	3.0	CL	0	3	07	40	20	18.2	0.25	10.5	102.4	102.4	102.4				1



COMPANY

JOB

EST. BY SGDATE 08/24/91

FORM ENG 5-A/7A

TABLE 2-2Average values of geotechnical parameters for TSA area

PARAMETER	MEAN VALUE	ST. DEVIATION	No. of SAMPLES CONSIDERED
Liquid Limit	45.3	5.4	6
Plasticity Index	24.6	5.4	6
Moisture content %	25.8	4.4	18
Dry density (pcf)	97.5	5.3	7
Optimum moisture	17.95	0.4	4
Max. dry density (pcf)	103.9	1.2	4
Hydraulic conductivity (cm/sec)	1.33×10^{-7}		4

Unit

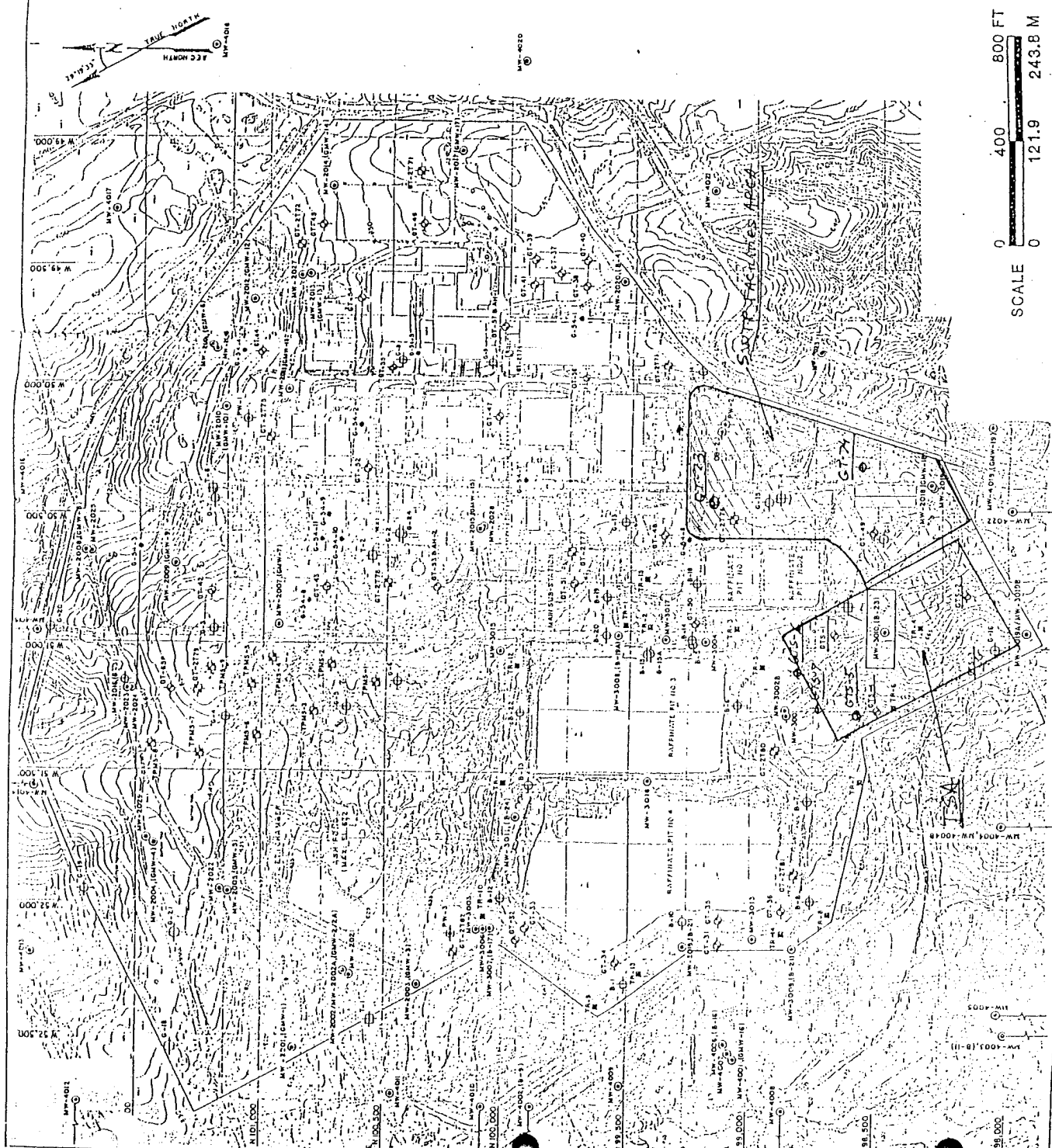
Ferrelview

Classification

CL - CH

Depth

approx 2' to 10'



LEGEND:

- 8M1 MONITOR WELL (1983), C.O.L.D. IN PARENTHESIS
 8H1 BOREHOLE (1983)
 BHI MONITORING WELL (1986), C.O.L.D. IN PARENTHESIS
 MKE PHASE I BOREHOLE (1989)
 MAF AND JIG MONITORING WELL (1989), INCLUDING
 INCORPORATED BHI WELLS (8 AND 8M1 SERIES)
 MKE PUMPING WELL (1988)
 MKE PHASE I TEST PIT (1988)
 MKE PHASE II BOREHOLE (1989)
 MKE TEST PIT (1990)

FIGURE 2-1













TEST PITS, MONITOR WELLS AND
BOREHOLES LOCATION MAP

ACTIVITY NO:	WP-238	DRAWING NO:	B/CP/126/1290
DESCRIPTION:	SDG	DRAWN BY:	GLN
		DATE:	12/90

APPENDIX B

GEOTECHNICAL BORING LOG LEGEND

SYMBOLIC LOG

	CLAY		GRAVELLY CLAY
	SILT		CLAYEY GRAVEL
	SAND		SANDY CLAY
	GRAVEL		TOPSOIL
	SILTY CLAY		SHALE
	CLAYEY SILT		CHERTY LIMESTONE

SAMPLER DESIGNATIONS

SS = STANDARD PENETRATION SAMPLER (2.0" SPLIT SPOON)

SB = CALIFORNIA SAMPLER (3.0" SPLIT BARREL)

$\frac{x}{x}$ = LINERS COLLECTED

ST = 3.0" SHELBY TUBE

P.P. = POCKET PENETROMETER, UNCONFINED COMPRESSIVE STRENGTH (Tons/Sq.Ft.)

GROUNDWATER MEASUREMENTS

6.5'; 6/9  = DEPTH & DATE OF INITIAL WATER LEVEL MEASUREMENT

2.9'; 6/16  = DEPTH & DATE OF STABILIZED WATER LEVEL MEASUREMENT

COLORS

SOIL & ROCK COLORS FROM MUNSELL SOIL AND GSA ROCK COLOR CHARTS

BOREHOLE LOG

Project Number: 5121

Hole Number
GTS-1

Temporary Storage Area

Hannibal Testing Labs.

Hole Size:	6 7/8"
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Depth Bottom of Hole: 39.8'

P. Patchin

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-6" (3)		
0							CLAYEY SILT, nonplastic, brown (10YR 4/3) w/roots, organics, FeOx nodules, v. stiff (2.75) last 1" 1.8
	1.0	SS		7"	2-3-4		mottled lt. yellowish brown (2.5Y 6/4) and yellowish brown (10Y 5/8), damp to dry. ML.
	2.5	SS			2-4-5		CLAYEY SILT (40% clay) slightly plastic, mottled lt. brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/8) FeOx) damp to dry, MnOx blebs, FeOx stain, ML-CL
	4.0	02		11"	9		
5	5.0	ST		12"			as above, damp, pp=2.5, non-plastic, ML
	7.5	03					FERRELVIEW
	7.5	SS		18"	2-3-5		
	9.0	04			8		SILTY CLAY, mottled as above, damp FeOx nodules (20% silt), slight to mod. plasticity. V. stiff 2.25 CL
10	10.0	ST		20"			CLAY med. to high plasticity, mottled lt. yellowish brown (2.5Y 6/4) and yellowish brown (10Y 5/8), damp, v. little silt, FeOx nodules, no MnOx, v. stiff (2.5) CL-CH.
	12.5	SS		18"	2-3-4		CLAY as above, with white non-calcareous soft inclusions, pp=3.0 CH
	14.0	06			7		FERRELVIEW
15	15.0	ST		28"			CLAY, gravelly (10%) mod. plasticity, mottled as above, slightly damp, abundant MnOx streaks, 16.3
	17.5	SS		17"	2-8-9		FeOx nodules. Gravel is subrounded igneous and metamorphics, very stiff (3.25) CL-CH
	17.5	08			17		CLAY TILL
	19.0						Clay gravelly as above, increased MnOx stringers and FeOx blebs to 7mm, igneous gravel to 2cm (15%) damp to dry. Sandy (5%) coarse, very stiff (3.75) CL
20	20.0	ST		29"			CLAY as above, sandy, predominantly yellowish brown (10YR 5/8) moist, pp=2.75 CL
	21.5	09					CLAY TILL
	22.5	SS			3-9-10		CLAY as above, no mottling; with hard L.S. gravel, vert. fractures w/MnOx, pp=3.75, sandy, dry to damp, CL
	24.0	10		18"	19		
25							See next page for sample ST11

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 2 of 2

BOREHOLE LOG

Project Number:

5121

Hole Number

GTS-1

Project:

Geotechnical Investigation - Phase II

Location:

Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
	25	25.0	ST 11	16"			Sampler drove rock & caved last 8" of Shelby tube. Cut off tube 8" from bottom. Rock was calcareous. Gravelly-
		27.2					CLAY as above, dry pp=3.5 CL
		27.5	SS		4-10-11		CLAY as above, abundant MnOx & fractures with leaching
		29.0	12	18"	21		pp=4.5 dry CLAY TILL
	30	30.0	SB		8-19-20		Pushed a large (7cm) rock at end of sampler. CLAY
		31.5	13	5"	39		as above, damp pp=3.
		32.5	SS		6-14-17		CLAYEY SAND to SILT (v. fine)(20% clay)lt.gray (10YR
		34.0	14	17"	31		7/2) nonplastic, dry to damp, abundant FeOx nodules to 3mm. Hard (> 4.0) no gravel mottled with lt.yellowish brn. (10YR 6/4) SC-ML BASAL TILL? 34.9
	35	35.0	SB		6-12-13		GRAVELLY CLAY, slight plasticity, yellowish red, no silt
		36.5	15	12"	25		(5YR 5/6) mottled with pinkish gray (5YR 6/2) 5% chert gravel to 12mm, minor finely xln L.S. (dark); damp, blocky, w/minor MnOx; FeOx blebs, hard (4.5) CL Residuum
		37.5	SS		7-11-20		Pushed rock, (lithographic limestone, gray 10YR 6/1)
		39.0	16	3"	31		GRAVELLY CLAY, as above, pp=4.5, dry 39.8
	40						Auger refusal @39.8' @8:40a.m. 5/12/89
							Note: In end of clean-out tube before grouting was large chert gravel (7cm) with weathering rinds and pyrite (fresh) inclusions. Also more leached looking clay.
							Collected bulk sample from 0-5.0' from auger cuttings.
							Grouted hole to surface with Volclay grout.
							Performed a constant head test at 36.5'. No take.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

Sheet 1 of 2

BOREHOLE LOG

Project Number:
5121Hole Number
GTS-2

Project: Geotechnical Investigation - Phase II		Location: Temporary Storage Area	
Coordinates: N.98100.4 W.50751.9 (AEC)		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME-55, 6 7/8" Hollow Stem Auger; 3 1/2" I.D.	Depth Top of Rock: 37.3'	Depth Casing & Size: none	Hole Size: 6 7/8"
Elevation: 668.17 ft. G.S.	Angle from Vert. and Bearing: Vertical	Depth Bottom of Hole: 37.3'	
Water Level: None	Fluid & Additives: None	Date Start: 5/9/89	Date Finish: 5/10/89
		Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
0	0		SS		2-6-7		SILTY CLAY, mod. plasticity, mottled light gray (10YR 7/1) and yellow (10YR 7/6), moist, roots, organics. CL. Bottom 6" is clayey silt, dk grayish brown (10YR 4/2) non-plastic, v. stiff (2.25) ML
	1.5		01	12"	13		
	2.5		ST				
	02			18"			
5	5.0						SILTY CLAY, low plasticity, mottled light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6) very stiff (2.25) damp, CL. FeOx blebs, MnOx stringers. Silt ~30-40%.
	5.0		SS		3-5-8		
	6.5		03	18"	13		
	7.5		ST				
10	04			28"			As above, pp=2.0 CL As above, pp=2.25 minor fine gravel, CL
	10.0						
	10.0		SS		7-9-10		
	11.5		05	18"	19		
15	12.5		ST				CLAY, as above, less silty (10%) high plasticity, moist, CH pp=2.5 CLAY as above, pp=2.75, high plasticity, damp, with slickensides, CL-CH
	15.0		06				
	15.0		SS		2-5-10		
	16.5		07	18"	15		
20	17.5		ST				FERRELVIEW Shelby tube sampler empty. Drove split barrel sampler to pick up sample. At end of split barrel was SILTY CLAY as above, dry, increase MnOx streaks, minor fine gravel, CL
	20.0		08	0"	Sample fell out no recovery		
	20.0		SS		2-4-6		
	21.5		09	18"	10		
25	22.5		ST				CLAY, as above but with increased (10%) fine gravel/coarse sand, dry, low plasticity, hard (3.75) CL CLAY TILL
	22.0						
	25.0						
	25.0		10	26"			

See next page for SS11 sample description

BOREHOLE LOG

Hole Number
GTS-2

Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-5"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
25	25.0	SS		18"	3-7-8		SILTY CLAY, gravelly (15%) low plasticity, dry, hard (4.25), gravel fraction subround igneous, mafic, possible metamorphic rock, sandy (10%), predominantly yellowish brown (10YR 5/8) CL as above pp=4.5 dry
	26.5	11		15			
	27.5	SB			4-7-14		
	29.0	12	12"	21			
30	30.0	SS		18"	5-7-12		CLAY TILL as above, less sand and silt, more plastic pp=4.0 gravel up to 3cm (chert). No sample, pushed rock. At end of split barrel is white (5Y 8/1) clay with decomposed L.S. CL
	31.5	13					
	32.5	SB		0"	4-11-12		
	34.0	14					
35	35.0	SB			13-39-30		RESIDUUM? CLAYEY GRAVEL, nonplastic, dry, gravel up to 5cm, white (5Y 8/1), weathered limestone and chert (90%) minor clay, white (5Y 8/2) and MnOx and FeOx staining; last
	36.5	15	12"		> 50		
					37.3'		4" is light gray (5Y 7/2) clay, "soapy", dry. Auger Refusal at 37.3' at 3:40pm 5/9/89
40							Note: Constant head tests at 10.0' and 25.0'. No take on both. Attempted test at 36.5' but could not seat NW drill rod due to rock. Took bulk sample from 0-5' from auger cuttings. Grouted hole to surface with Volclay grout.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number:
5121

Hole Number
GTS-3

Project: Geotechnical Investigation - Phase II		Location: Temporary Storage Area	
Coordinates: N.93118.6- W.51076.9 (AEC)		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME-55, 6 7/8" Hollow Stem Auger with 3 1/4" I.D.		Depth Top of Rock: 31.5'	Depth Casing & Size: none
Elevation: 654.97 ft. G.S.		Angle from Vert. and Bearing: Vertical	
Water Level: None		Date Start: 5/5/89	Date Finish: 5/8/89
Fluid & Additives: None		Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
0							Augered to 2.5'
							FERRELVIEW
	2.5 4.0	SS 01	5"	2-1-1 2			SILTY CLAY, low plasticity, dark yllwsh brn(10YR 3/4) mottled with yellowish red (10YR 4/6), moist, soft (.75) CL
5	5.0 7.5	ST 02	17"				CLAY, high plasticity, mottled red (2.5YR 4/8) and brn (10YR 5/3), minor black (MnOx) streaks, moist, med. stiff (1.0) CH
	8.0 9.5	SS 03	11"	2-7-8 15			CLAY, as above, light gray (10YR 7/1), slightly silty, no mottling, moist, stiff (1.5), CH
10	10.0 12.5	ST 04	28"				SILTY CLAY, 15% silt, low to med plasticity, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1) with abundant FeOx nodules and MnOx streaks, damp, very stiff (4.0), CL
	12.5 14.0	SS 05	18"	1-8-9 17			As above, grading to siltier (~30%) minor fine sand and gravel at bottom, v. stiff (3.0) CL
15	15.0 17.5	ST 06	29"				CLAY TILL SILTY CLAY, low plasticity, yellowish brown (10YR 5/6) mottled with light gray (5Y 7/2), damp very stiff (4.0) approx. 15% fine gravel (igneous & metamorphic) subrnd abundant FeOx blebs & MnOx stringers. CH
	17.5 19.0	SS 07	10"	3-12-18 30			SANDY GRAVEL, nonplastic, white (10YR 8/1) 60% large angular chert gravel, (gray 10YR 6/1) up to 2cm, minor clay (5%), minor FeOx stain; dry. GM
20	20.0 22.5	ST 08	16"				BASAL TILL CLAY, low to med plasticity, white, (5Y 8/1), damp, blocky, stiff, (2.0) with FeOx and MnOx stringers, "soapy", with approx. 25% decomposed limestone? (high reaction to HCL) CL.
	22.5 24.0	SS 09	12"	9-10-15 25			As above, increase in FeOx stain, with very angular pale blue chert, pp=2.0
25							RESIDUUM?

See next page for SB11 Sample description.

Sheet 2 of 2

Project Number. 5121

Hole Number GTS-3

Location:

Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
	25	25.0	SB		13-14-15		CLAY, gravelly, light brownish gray (2.5Y 6/2), mod. to high plasticity, with FeOx staining (10YR 6/6) & MnOx stringers; stiff (1.23) 25% subangular chert gravel to 4cm, no limestone, CL RESIDUUM?
	X 26.5	10	6"	29			GRAVEL, with minor clay, nonplastic, dry 10% clay, gravel is cherty limestone to 3cm, also sand size decomposed rock, all stained with FeOx, GC.
	27.5	SS		10-22-23			
	29.0	11	10"	45			
	30.0						
	30	X 30.0	SB12	6"	50-750		As above w/50% clay to 30.2', gravel (cont'd below)
	30.5			refusal			AUGER REFUSAL RESIDUUM? 31.5
							@8:50 am 5/8/89
							is predominantly chert gravel. At 30.2 is weathered bedrock with mainly chert and clay (brownish yellow 10YR 6/6), chert pieces to 4cm. Also white clay (5Y 8/1) with MnOx stringers. FeOx stain throughout with minor weathered limestone and limey clay.
							Grouted hole to surface with Volclay grout.
							Note: Performed constant head test at 7.5', 17.5', and 22.5'. No take on all tests.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number:

5121

Hole Number

GTS-4

Project: Geotechnical Investigation - Phase II		Location: Temporary Storage Area	
Coordinates: N.98448.6 W.51237.2 (AEC)		Drilling Contractor: Hannibal Testing Labs	
Drill Make and Model: CME 55, 6 7/8" Hollow Stem Auger: 3 1/2" I.D.		Depth Top of Rock: 27.3	Depth Casing & Size: none
Elevation: 652.20 ft. G.S.		Angle from Vert. and Bearing: Vertical	
Water Level: None		Date Start: 5/10/89	Date Finish: 5/11/89
Fluid & Additives: None		Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
0		00	SS		3-7-6		CLAYEY SILT, non-plastic, dark brn (10YR 3/3) abund. roots & organics, moist. Last 3" brn (10Y 5/3) w/med. gravel & drv ML. TOPSOIL/FILL 2.0
	1.5	01		9"	13		
	2.5	ST					SILTY CLAY, slight plasticity, mottled brn (10YR 5/3) & strong brn (7.5YR 5/6), dry to damp, abund. FeOx stn, 25% silt, occasional blk organic? blebs, v. stiff (2.25) CL
5	5.0	02		27"			
	5.0	SS			2-3-6		CLAYEY SILT (~30% clay) non-plastic, mottled lt. grnsh gray (10YR 6/2) & brnsh yellow (10YR 6/8), dry to damp, w/bl organic? blebs (prob. FeOx), v. stiff (2.25) ML
	6.5	03		16"	9		
	7.5	ST					FERRELVIEU
	10.0	04		30"			As above, increased SILT (80-90%) w/FeOx blebs, more lt. brnsh gray (10YR 6/2), damp, stiff (1.75) ML 10.3
10	10.0	SS		18"	2-5-7		
	11.5	05			12		CLAY, gravelly, mod. plasticity, mottled yellowish brn (10YR 6/8) and lt. gray (minor) (10YR 7/1), chert gravel (subrnd) fine to 1cm (10%) minor sand, abund FeOx nods & MnOx stringers, v/stiff (2.25). CL-CH
	12.5	ST		30"			As above, sandier, less mottling, pp=3.25, w/vert & horiz. fractures w/MnOx staining and leaching, dry-damp CL.
15	15.0	06					As above, pp=3.5, no mottling; slight to mod. plasticity. CL-CH
ave 6"	16.5	SS		16"			CLAY TILL
	17.5	ST					CLAY, mod. plasticity, lt. yellowish brn (10YR 6/4), hard (4.25) abund FeOx blebs 5% rounded gravel, v. little sand, dry to damp, no fractures, CL-CH
	20.0	08		26"			
20	20.0	SS		15"	4-8-7		As above, pp=3.75, abund angular chert gravel @20.5 for 4" yellowish brown (10YR 5/7) abund. MnOx streaks; damp, no L.S. CL-CH
	21.5	09			15		
	22.5	SB			8-15-5		
	24.0	10		6"	20		CLAYEY GRAVEL, w/angular chert gravel up to 6cm in diam. (possible silicified L.S.) BASAL TILL? 22.8
25							GRAVELLY CLAY, slt. plasticity, wh. (5Y 8/2) mottled w/brnsh ylw (10YR 6/8) mottling, 20% chert RESIDUUM 23.7

See next page for sample SB11

(ang) gravel (pieces) up to 5cm long, vuggy w/wthring rinds, clay is moist and talc-like, no L.S., CL-CH

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2Project Number:
5121Hole Number
GTS-4

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SYMBOLIC LOG	SOIL DESCRIPTION
		INTERVAL	TYPE & NUMBER	RECOVERY	6"-6"-6" (N)		Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
25	X	25.0	SB	6"	17-19-12	9/4 9/4 9/4	CLAYEY GRAVEL, nonplastic 20% clay is "talc like", lt olive yellow (10YR 6/6), damp, w/ abund. FeOx, also decomposed L.S (HCL reaction), angular chert gravel loose silty matrix, GC Auger refusal @ 27.5' @ 3:50pm 5/10/89 Note: GTS-4 Bulk Sample taken from 0-5.0' from auger cuttings. Grouted hole to surface with Volclay grout. Constant head test at 5.0' and 24.0'. No take on both.
		26.5	11				
30							RESIDUUM? 27.5

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Contract WP117

Hole Number

GTS-5

Project: Geotechnical Investigation Phase II		Location: Temporary Storage Area	
Coordinates: N.98607.7 W.51245.8 (AEC)		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME-55 H.S. Augers 6-7/8", 3 1/4"		Depth Top of Rock: 37.0	Depth Casing & Size: None
Elevation: G.S. 662.64 ft.		Angle from Vert. and Bearing: Vertical	
Water Level: Dry		Fluid & Additives: None	Date Start: 12:50 6/5/89
			Date Finish: 11:10 6/6/89
			Logger: A. Benfer

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
	GTS-5 Bulk						(Bulk sample of cuttings, GTS-5, collected from 0 to 5.0 feet).
	2.5						
	5.0		ST 01	29"			CLAY, highly plastic, mottled brownish yellow (10YR 6/6) and dark gray (10YR 4/1), moist, minor black, stiff to very stiff (2.0), CH, contains minor rounded limestone gravel (1/8"), possible fill.
	6.5		SS 02	13"	2.2.2 4		As above, bottom 2" mottled blue and olive gray (5Y 5/2) with decomposed grass.
							FILL 7.5
	7.5		ST 03				SILTY CLAY, low plasticity, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1), moist very stiff (2.25), CL, minor FeOx.
	10.0			19"			
	10.0		SS 04	17"	2.4.4 8		As above, mostly light yellowish brown (10YR 6/4), with ~20% black FeOx, pp=2.2
	11.5						FERRELVIEW 12.5
	12.5		ST 05				CLAY, highly plastic, mottled yellowish brown (10YR 5/6) and gray (10YR 6/1), moist, stiff (1.5), CH. Contains ~10% FeOx and <5% spherical nodules (1/8"), trace limestone sand.
	15.0			20"			
	15.0		SS 06	18"	2.1.3 4		As above, pp=2.2, 16.0-16.5, 5% sand.
	16.5						
	17.5		ST 07				Disturbed
	20.0			23"			FERRELVIEW 20.5
	20.0		SS 08	18"	2.2.5 7		SILTY CLAY, medium plasticity, 10% sand, 10% fine subrounded gravel, brownish yellow (10YR 6/6) with black MnOx stringers, moist, very stiff (3.0), CH.
	21.5						
	22.5		ST 09	32"	Pushed 24"		As above, mottled with light gray (10YR 7/1), less sand and gravel, pp=3.0.
	24.5						CLAY TILL

5/89
39

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 2

Project Number: 5121

Contract WP117

Hole Number

GTS-5


BOREHOLE LOG

Project

Geotechnical Investigation Phase II

Location:

Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
5/5/89 5/6/89	25	25.0	SS		2.6.3		26.0-28.0 as above, increase in gravel >50%, predominantly chert, up to 2", subrounded, pp(clay)=3.5.
		26.5	10	18"	19		
		27.5	SB		7.12.16		As above, pp=4.5+, hard, 15% fine to coarse sand, trace gravel (1/4"), MnOx stringers.
		29.0	11	12"	28		
	30	30.0	SS		4.7.11		CLAY TILL SILTY CLAY, medium plasticity, ~15% sand, mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1) damp, hard, (>4.5), CL-CH, spherical FeOx, MnOx stringers and blebs.
		31.5	12	18"	18		
		32.5	ST 13				
		35.0		34			As above, pp=3.0, very stiff, CH.
	35	35.0	SS		3.9.50		
		36.5	14	18"	59		GRAVEL fragments, chert, 10% clay, chert-yellowish brown (10YR 5/6), also clay with black MnOx, clay moist, hard, GC. RESIDUUM
							Auger refusal at 37.0, T.D. 11:10 6/6/89 Apparent bedrock Grouted hole with 2 bags of Volclay Constant head test at 15.0'. Take = .25 oz. in 10 minutes.

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Contract WP117

Hole Number

GTS-6

Project:

Geotechnical Investigation Phase II

Location:

Temporary Storage Area

Coordinates:

N.98933.0 W.51035.7 (AEC)

Drilling Contractor:

Hannibal Testing Laboratories

Drill Make and Model:

CME-55 H.S. Auger 6 7/8", 3 1/4"

Depth Top of Rock:

47.0

Depth Casing & Size:

None

Hole Size:

6 - 7/8"

Elevation:

G.S. 665.28 ft.

Angle from Vert. and Bearing:

Vertical

Depth Bottom of Hole:

47.0

Water Level:

Dry

Fluid & Additives:

None

Date Start:

3:00 6/6/89

Date Finish:

1:25 6/7/89

Logger:

A. Benfer

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-4"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
5	GTS-6 Bulk						(Bulk sample of cuttings, GTS-6, collected from 0 to 5.0 feet).
		2.5 4.0	SS 01	9"	3.6.8		SILT, nonplastic, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/2), damp, hard (4.5+), ML.
		5.0 7.5	ST 02	24"			FERRELVIEW As above, pp=4.5+, hard, light yellowish brown (10YR 6/4)
10		7.5 9.0	SS 03	18"	3.5.7 12		SILTY CLAY, low to medium plasticity, mostly light yellowish brown (10YR 6/4) with yellowish brown (10YR 5/6), moist, very stiff to hard (4.0), CL. Up to 1/8" blebs MnOx.
		10.0 12.5	ST 04				FERRELVIEW As above, pp=4.1, hard, mottled yellowish brown (10YR 5/6) and lt. gray (10YR 7/1), abundant FeOx. 12.5
		12.5 14.0	SS 05	12"	2.3.5 8		CLAY, highly plastic, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1), moist, very stiff (2.5), CH. Slickensided, contains: MnOx and FeOx.
15		15.0 17.5	ST 06	26"			As above, pp=3.1 FERRELVIEW
		17.5 19.0	SS 07	18"	3.4.6 10		As above, pp=2.5, very stiff, slickensided with stringers and blebs of MnOx and spherical FeOx nodules
		20.0 22.5	ST 08	30"			As above, pp=3.75, 5% white angular sand 22.5
		22.5 24.0	SS 09	18"	4.6.10 16		SILTY CLAY, highly plastic, 15% sand, 10% subrounded fine gravel, spherical FeOx, reddish yellow (7.5YR 6/6) with light gray (10YR 7/1), damp, hard (4.5+) CL-CH. Minor MnOx.
							CLAY TILL

6/89
7/89

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 2

Project Number: 5121
Contract WP117

Hole Number

GTS-6

BOREHOLE LOG

Project:

Geotechnical Investigation Phase II

Location:

Temporary Storage Area

SOIL DESCRIPTION

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-8" (2)	SYMBOLIC LOG	Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol.
		INTERVAL	TYPE & NUMBER	RECOVERY			
25		25.0	ST 10				
		27.5		28"			As above, pp=4.5+, increase in MnOx
		27.5	SS		4.6.8		
		29.0	11	18"	14		As above, pp=3.0, very stiff, less sand and gravel
30		30.0	SB	3	8.10.13		SILTY CLAY, medium plasticity, 10% sand, 10% fine gravel, brownish yellow (10YR 6/6) with minor light gray (10YR 7/1), damp, very stiff (3.25), CL. FeOx and MnOx stringers.
		31.5	12	12"	23		
		32.5	SS		5.7.10		
		34.0	13	15"	17		As above, pp=4.5+, hard, slickensided with MnOx
35		35.0	SB		9.18.24		
		36.5	14	12"	42		As above, pp=4.3 CLAY TILL
		37.5	SS		5.7.10		Hard drilling
		39.0	15	18"	17		As above, pp=3.75, spherical FeOx, granitic rock fragments, some well rounded fine gravel.
40		40.0	SB		11.22.35		As above, at 40.5', mottled red (2.5YR 5/8) and light gray (10YR 7/1), moist, hard (4.5+).
		41.5	16	12"	57		
45		45.0	SS		5.15.43		GRAVEL, 30% clay, predominantly chert, brownish yellow (10YR 6/6) and black (MnOx), damp, hard (4.5+).
		46.5	17	18"	58		GC, bottom 2" chert, highly fractured. RESIDUUM
							Auger refusal 47.', T.D. 1:25 6/7/89 Probably bedrock Grouted hole with 2 bags Volclay

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2Project Number: 5121
Contract WP117Hole Number
GTS-7

Project: Geotechnical Investigation Phase II		Location: Temporary Storage Area	
Coordinates: N.98771.0 W.51381.8 (AEC)		Drilling Contractor: Hannibal Testing Laboratories	
Drill Make and Model: CME-55 H.S Auger 6-7/8", 3-1/4"		Depth Top of Rock: 44.5	Depth Casing & Size: None
Elevation: G.S. 662.07 ft.		Angle from Vert. and Bearing: Vertical	
Water Level: Dry		Fluid & Additives: None	
Date Start: 8:45 6/8/89		Date Finish: 2:00 6/8/89	
Logger: A. Benfer		Hole Size: 6-7/8"	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-8"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
							(Bulk sample of cuttings GTS-7 Bulk, collected from 0 to 5.0 feet). FILL
		2.5 4.0	SS 01	4"	3.3.5 8		SILTY CLAY, low plasticity, dk yellowish brn (10YR 4/2) dry, hard (4.5+), CL, localized angular gravel. 3.5
5		5.0	ST				SILTY CLAY, medium plasticity, mottled strong brown (7.5YR 5/6) and yellow (10 YR 7/3), moist, stiff to very stiff (2.0), CL. Contains black MnOx. FERRELVUE
		7.5 7.5 9.0	02 SS 03	32" 14"	1.3.5 8		CLAY, low plasticity, very silty, yellow (10YR 7/4) very stiff (3.0), CL. MnOx and FeOx blebs. 9.0
10		10.0	ST				CLAY, highly plastic, mottled yellowish red (5YR 6/6) and light gray (7.5YR 7/0). moist, very stiff (2.25), CH.
		12.5 12.5 14.0	04 SS 05	20" 18"	3.4.5 9		As above, mostly light gray (10YR 7/1) with strong brown (7.5 YR 5/6) (FeOx), pp=2.75. As above, minor MnOx, spherical FeOx, pp=3.5.
15		15.0	ST				FERRELVUE
		17.5 17.5 19.0	06 SS 07	22" 18"	3.5.10		As above, trace sand and fine gravel, pp=2.75. 17.5 SILTY CLAY, 20% sand, mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1), damp, hard (4.5+), CL-CH. Slickensided, MnOx blebs.
20		20.0	ST				CLAY TILL
		22.5 22.5 24.0	08 SS 09	20" 16"	3.5.6 11		As above, 15% sand, 5% subrounded gravel, pp=3.7, CH. As Above, pp=4.5+, MnOx stringers. trace gravel up to 1/2".

WELDON SPRING REMEDIAL ACTION PROJECT

Sheet 2 of 2

Project Number: 5121

Contract WP117

Hole Number

GTS-7

BOREHOLE LOG

Project

Geotechnical Investigation Phase II

Location:

Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		INTERVAL	TYPE & NUMBER	RECOVERY			
		X 25.0 SB			7.15.27		As above, stiff (1.5), moist, CL, stringers of CaCO ₃ and MnOx, some well rounded coarse sand.
		X 26.5 10	18"		42		
		27.5 SS			4.7.9		As above, pp=4.5+, 10% fine gravel, vertical light gray clay stringers. CLAY TILL
		29.0 11	18"		16		
		X 30.0 SB			17.38.28		CLAY, silty, 10% sand, 10% gravel up to 1", brownish yellow (10YR 6/6) with light gray (10YR 6/6) stringers, spherical FeOx, damp hard (4.5), CL.
		X 31.5 12	12"		66		
		32.5 SS			4.7.11		As above, reddish yellow (7.5YR 6/8) at 33.5, pp=4.5, slickensided some with MnOx film.
		34.0 13	18"		18		
35		35.0 SB			11.15.26		As above, yellowish brown (10YR 6/6)
		X 36.5 14	12"		41		
		37.5 SS			7.11.8		37.5-38.0 SAND, fine to coarse, 20% clay, strong brown (7.5YR 5/6), damp, medium dense, SC. 38.0-39.0 CLAY, medium plasticity, light gray (10YR 7/1) moist, medium stiff to stiff (1.0), CL-CH, with white lithographic limestone fragments.
		39.0 15	18"		19		
40		X 40.0 SB			5.9.2		40.0-41.5 CLAY, low plasticity, speckled yellowish brown (10YR 7/1), moist, very stiff (2.5), CL, minor MnOx, abundant FeOx up to 1/4" nodules. CLAY TILL
		X 41.5 16	12"		11		
							Auger refusal 44.5', T.D., 2:00 6/8/89 Probable bedrock Hole grouted with 2 bags Volclay.

BOREHOLE LOG

PAGE 1 OF 2

REF ID: _____ LOCATION ID: GF-73

COORDINATES (FT.): _____

GROUND ELEVATION (FT. MSL): _____

DRILLING METHOD: 3 3/4" ID. Auger

DRILLING CONTR.: GEO TECHNOLOGY

DATE STARTED: 4/15/91 11:20

DATE COMPLETED: 4/15/91 16:10

FIELD GEOLOGIST/ENGINEER: E Ren

GROUNDWATER LEVELS

DATE	TIME	DEPTH (FT.)
4/15/91	1510	DRY

LOCATION DESCRIPTION ~100' W of SW

corner of Bldg 302

SITE CONDITION Grassy level

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	SAMPLE SPM (OPT) NO	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION
						Top: dk brown silt (ML) w/ organics contaminated (~400 cts/min); moist
	2 1/2 - 4 SPT	13"	7301	2-4-6		- 3' + 1/2" Med brn silty clay (CL); moist plastic
- 5	5-7 1/2 ST	28"	7302			A.A. more silty; some gray color
	7 1/2 - 9 SPT	16"	7303	1-5-8		A.A.
	10-12 1/2 ST	4"	7304 no sample			AA - single 1" angular chert clast
	12 1/2 - 14 SPT	16"	7305	1-4-7		AA mostly lt gray; clayey again.
- 15	15-17 1/2 ST	23"	7306			AA stiff, Mn staining; some Fe staining lt brn & gray
	17 1/2 - 19 SPT	20"	7307	4-8-12		7 1/2" + Lt Gray-brown silty clay (CL) plastic, moist w/ ~5% subrounded med-cse chert sand slight Mn & Fe staining
- 20	20-22 1/2 ST	28"	7308			AA more staining
	22 1/2 - 24 SPT	18"	7309	5-8-12		AA lt orange-brown color
- 25	25-27 1/2 ST	27"	7310			AA lt gray & brown
	27 1/2 - 29 SPT	21"	7311	5-12-16		A.A. occ'l whitish Limestone medl - fizzes w/ HCl
- 30	30-32 1/2 ST	23"	7312			7312 - pushed 20", end badly crimped

REMARKS: AA = A₂ Above SPT = Std. Penetration Test ST = Sl. lb. T. he

BOREHOLE LOG

PAGE 2 OF 2

ITEM ID: _____ LOCATION ID: CT-73

COORDINATES (FT.): _____

_____ E _____

GROUND ELEVATION (FT. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.: _____

DATE STARTED: _____

DATE COMPLETED: _____

FIELD GEOLOGIST/ENGINEER: _____

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	SAMPLE GPM (OPT) No.	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION
						A.A. occ'l gravel-size clasts
	32 1/4 - 34 SPT	21"	7313	6-10-11		A.A. - up to 10% fine gravel
- 35 -	35-36 1/2 CS	19" (3 tubes)	7314	(7-11-15)		33 1/2' + softer gray clayey silt (ML) little sand no gravel; some Fe staining A.A.
	37 1/2 - 38 SPT	17"	7315	5-9-20		38' + - Lt-dark brown clayey silty sand w/ occ'l small angular gravel; Fe staining
0	40-41 1/2 CS	15" (2 tubes)	7316	(24-37-100/4")		chert 40' + Whitish angular gravel (~60%) (GW-6M) w/ sandy clayey silt white-orange, slt Fe staining AA more gravel, broken by pounding
- 45 -	42 1/2 - 44	7"	7317	34-50/2 1/2"		Auger refusal at 45 1/2'
						Grouted w/ 5 bags Yolclay at 9.4; 9.6; 9.7 lbs/gal

COMMENTS: CS = California sampler

15:00

WELDON SPRING SITE REMEDIAL ACTION PROJECT BOREHOLE LOG

PAGE 1 OF 2

SITE ID: _____ LOCATION ID: GT-74
TE COORDINATES (FT.): _____

GROUND ELEVATION (FT. MSL): _____

DRILLING METHOD: 3 3/4" I.D. Auger

DRILLING CONTR.: GEOTECHNOLOGY

DATE STARTED: 4/12/91 14:00

DATE COMPLETED: 4/15/91 10:00

FIELD GEOLOGIST/ENGINEER: E. Rount

GROUNDWATER LEVELS

DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION ~150' NE of

Rd 434

SITE CONDITION Grassy, inclined to

NE

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	Z VALUE	VISUAL CLASSIFICATION
						Med brn silty clay (CL) moist, plastic organics (A brn) n. top, some gross occl chert clast (up to 1/2").
	2 1/2 - 4 SPT	5"	7401	2-3-6		
5	5 - 7 1/2 ST		7402			~6' + Med gray silty clay (CL) moist, Plastic
	7 1/2 - 9 SPT	12"	7403	1-4-6		Mottled lt brn - lt med gray silty clay (CL) moist, plastic
10	10 - 12 1/2 ST	77"	7404			~11' + ~24" brn-orange clay (CL) moist, <u>Clay Till</u> stiff, plastic; ~5% rounded med sand (chert) - subrounded Fe, Mn ox. occl up to 1/4"
	12 1/2 - 14 1/2 SPT	18"	7405	1-5-7		
15	15 - 17 1/2 ST	~6"	7406			17 1/2' - ~10% subrounded fine gravel (dk gray)
	17 1/2 - 19 SPT	18"	7407	3-8-9		- AA stiff
20	20 - 22 1/2 ST	22"	7408			~14" - pushed 28"; end badly crimped AA?
	22 1/2 - 24 SPT	22"	7409	3-8-9		AA
25	25 - 27 1/2 ST	24"	7410			- pushed 26" AA
	27 1/2 - 28 SPT	~14"	7411	1-23-25		28' + ~80% angular chert gravel white → Fe stained
	28 - 29 1/2 CS	7"	=====	(100/5 1/2")		no sand here 1-2" angular chert ~70% with some clay

COMMENTS: _____

PAGE 2 OF 2

FIELD GEOLOGIST/ENGINEER: _____

DATE

TIME =

DEPTH (FT.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

REMARKS:

angular
Chert Grains! w/ limestone encrusting.

TD = 34 1/2'

Grouted w/ 3 bags Volclay
at 9.6 lbs/gal

APPENDIX C

Request No.	Sample I.D.	Sample No.	Depth (ft)	Confining Pressure (ksf)	Reported Value		Corrected Value	
					Total Head (ft)	Permeability (cm/sec)	Total Head (ft)	Permeability (cm/sec)
4	GT-60P	SB-15	40.5 - 41.0	4	64.3	9×10^{-9}	11.6	7×10^{-8}
	GT-60P	SB-15	41.0 - 41.5	7	112.5	2×10^{-8}	11.6	2×10^{-7}
	GT-60P	SB-17	48.5 - 49.0	4	64.3	6×10^{-8}	11.6	3×10^{-7}
	GT-60P	SB-17	48.5 - 49.0	7	112.5	2×10^{-8}	11.6	2×10^{-7}
	GT-62	ST-07	17.5 - 20.0	2	32.1	2×10^{-8}	11.6	5×10^{-8}
	GT-62	ST-07	17.5 - 20.0	4	32.1	No Flow	11.6	$< 1 \times 10^{-9}$
	GT-62S	SB-13	32.8 - 33.3	3	48.2	6×10^{-8}	11.6	3×10^{-5}
	GT-62S	SB-13	32.8 - 33.3	5	80.3	7×10^{-9}	11.6	6×10^{-8}
	GT-63P	ST-01	2.5 - 5.0	1	16.1	5×10^{-9}	11.6	7×10^{-9}
	GT-63P	ST-09	22.5 - 25.0	2	32.2	3×10^{-9}	11.6	9×10^{-9}
	GT-65S	SB-16	41.0 - 41.5	4	64.2	2×10^{-7}	11.6	8×10^{-7}
	GT-65S	SB-16	41.0 - 41.5	7	112.4	3×10^{-8}	11.6	4×10^{-7}
5	GT-67P	ST-08	20.0 - 22.5	2	32.2	4×10^{-8}	11.6	1×10^{-7}
	GTS-1	ST03	5.0 - 7.5	1	16.1	1×10^{-7}	11.6	2×10^{-7}
	GTS-3	ST02	5.0 - 7.5					
	GTS-2	ST02	2.5 - 5.0	1	16.1	6×10^{-8}	11.6	8×10^{-8}
	GTS-4	ST04	7.5 - 10.0					
	GTS-4	ST02	2.5 - 5.0	1	16.1	2×10^{-7}	11.6	2×10^{-7}
	GTS-4	ST04	7.5 - 10.0					
	GTS-5		0.0 - 5.0	1	16.1	2×10^{-8}	11.6	2×10^{-8}
	GTS-6		0.0 - 5.0	1	16.1	9×10^{-8}	11.6	1×10^{-7}
	GTS-7		0.0 - 5.0	1	16.1	3×10^{-8}	11.6	5×10^{-8}



Request #5

P.O. # 3589-1002-3445

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WJRAP

CHECKED BY: LAE 47

DATE: 11-9-89

TAC: _____

LAB NAME: Geotechnology Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTS-1	ST03	TOP 5.0-7.5	26.7	N/A
GTS-1	ST03	MIDDLE 5.0-7.5	23.3	97.5
GTS-1	ST03	BOTTOM 5.0-7.5	22.8	N/A
GTS-2	ST02	TOP 2.5-5.0	29.2	N/A
GTS-2	ST02	MIDDLE 2.5-5.0	25.5	95.0
GTS-2	ST02	BOTTOM 2.5-5.0	26.6	N/A
GTS-2	ST04	TOP 7.5-10.0	20.5	103.0
GTS-2	ST04	BOTTOM 7.5-10.0	20.7	102.1
GTS-3	ST02	TOP 5.0-7.5	28.9	N/A
GTS-3	ST02	MIDDLE 5.0-7.5	29.6	89.9
GTS-3	ST02	BOTTOM 5.0-7.5	37.4	N/A
GTS-4	ST02	TOP 2.5-5.0	28.2	N/A
GTS-4	ST02	MIDDLE 2.5-5.0	28.4	92.3
GTS-4	ST02	BOTTOM 2.5-5.0	28.1	N/A
GTS-4	ST04	TOP 7.5-10.0	26.7	N/A

TEST PROCEDURE: ASTM D2216 & D2937

Report #5

P.O. # 3589-1002-3445

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WNPAP

CHECKED BY: LAB 44

DATE: 11-9-85

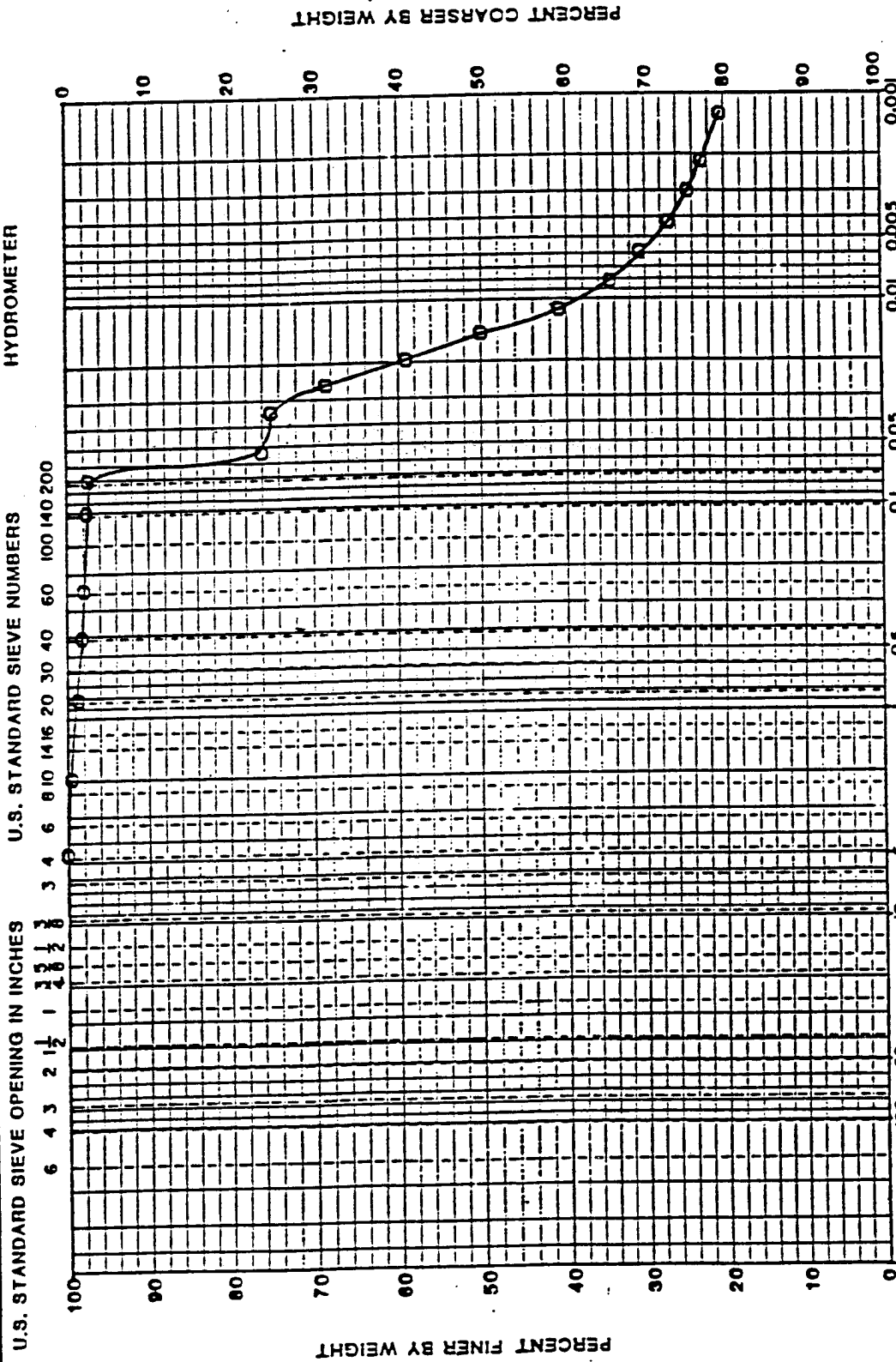
TAC: _____

LAB NAME: Geotechnology, Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTS-4	STO4	MIDDLE 7.5-10.0	21.5	102.9
GTS-4	STO4	BOTTOM 7.5-10.0	21.5	N/A
GTS-5	BULK	0.0-5.0	21.7	N/A
GTS-6	BULK	0.0-5.0	19.7	N/A
GTS-7	BULK	0.0-5.0	23.8	N/A

TEST PROCEDURE: AJTM D2216 & D2937

GRAD/ CURVES



SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
ST-03	5.0-7.5	CL	25.2	40	20	20	YSSRAP
BORING NO. GTS-1							DATE
11-8-88							

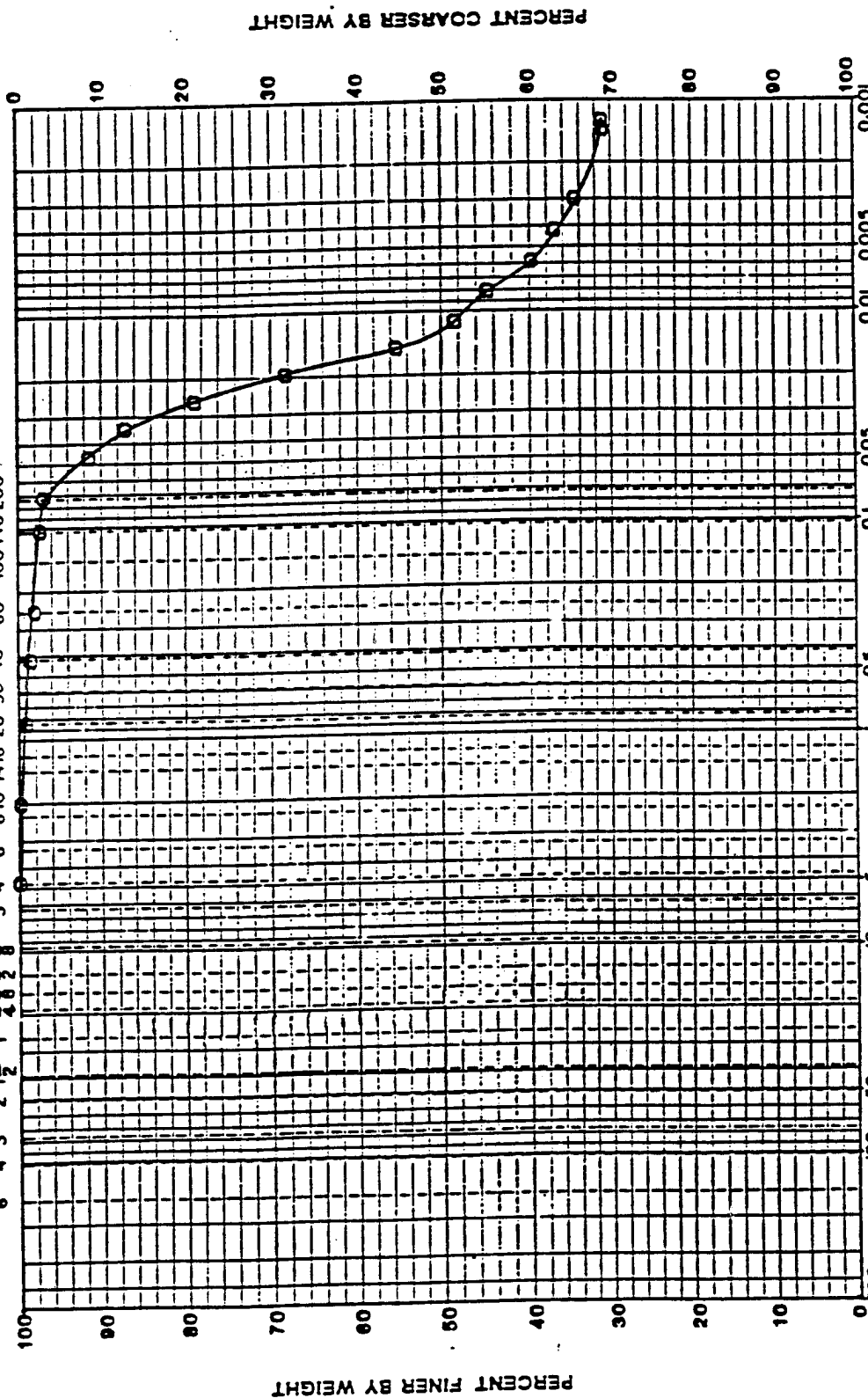
GRADE CURVES

HYDROMETER

U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES

6 4 3 2 1 1/2 1 3/4 2 1/4 3 4 6 10 14 20 30 40 60 100 140 200



GRAIN SIZE IN MILLIMETERS

COBBLES	GRAVEL		SAND			SILT OR CLAY	
	COARSE	FINE	COARSE	MEDIUM	FINE		

PROJECT WSSRAP

BORING NO. GTS-2

DATE 11-8-88

GEOTECHNOLOGY

CLASSIFICATION

EL. or DEPTH

SAMPLE NO.

2.5-10.0

COMP.

CL

NAT. WT. %

5.4

LL

44

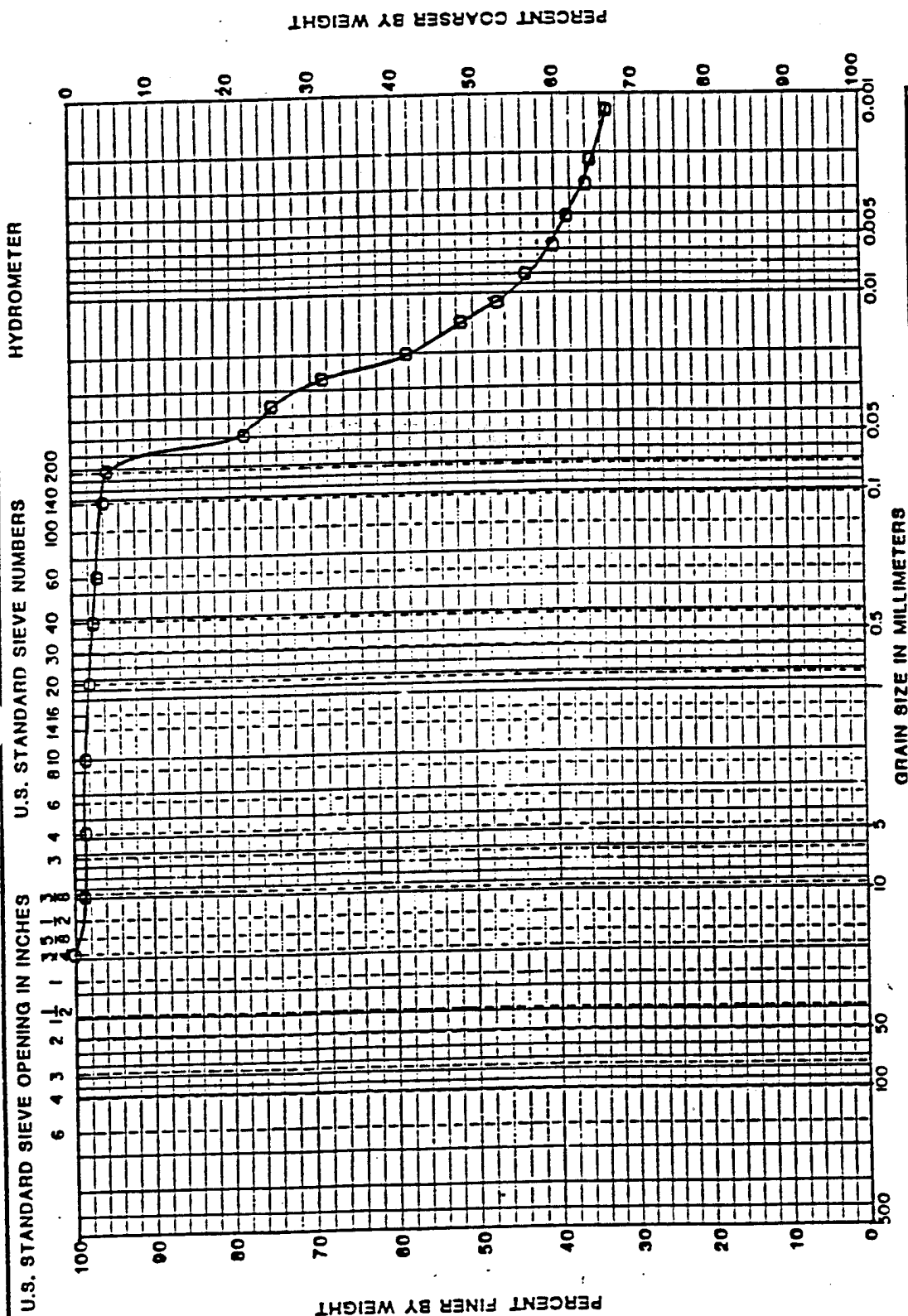
PL

20

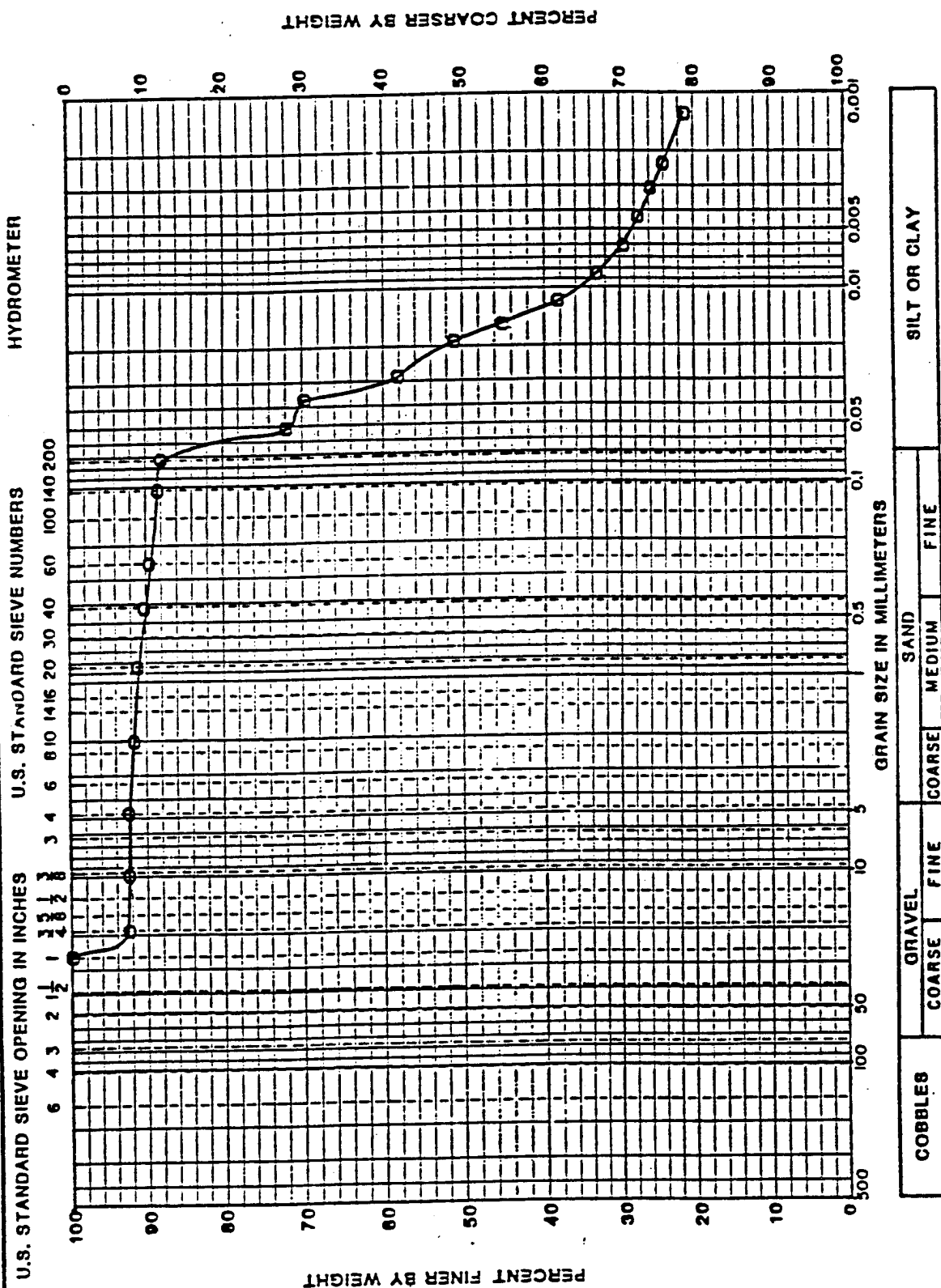
PI

24

GRADE CURVES



GRAT CURVES



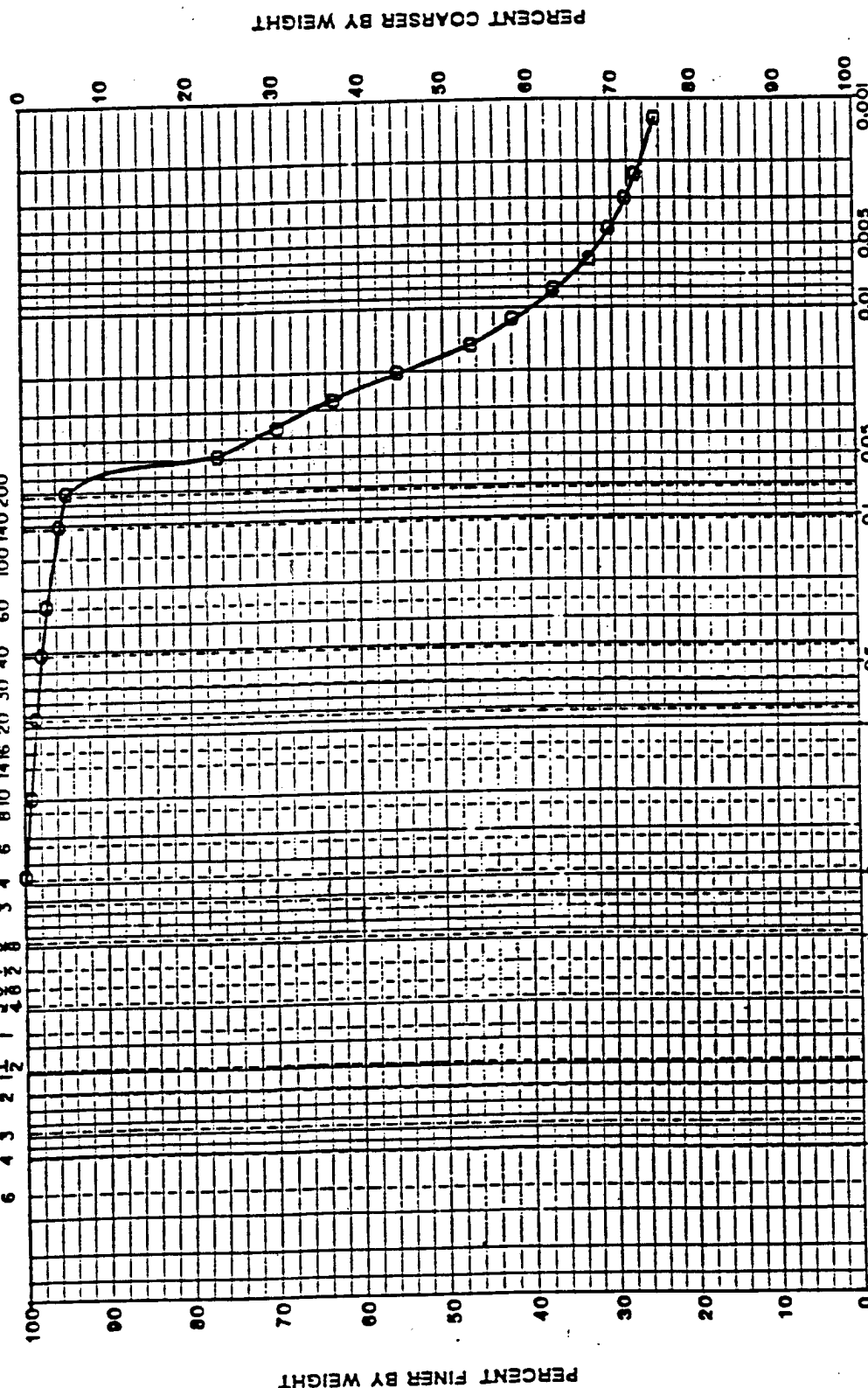
GRADE CURVES

HYDROMETER

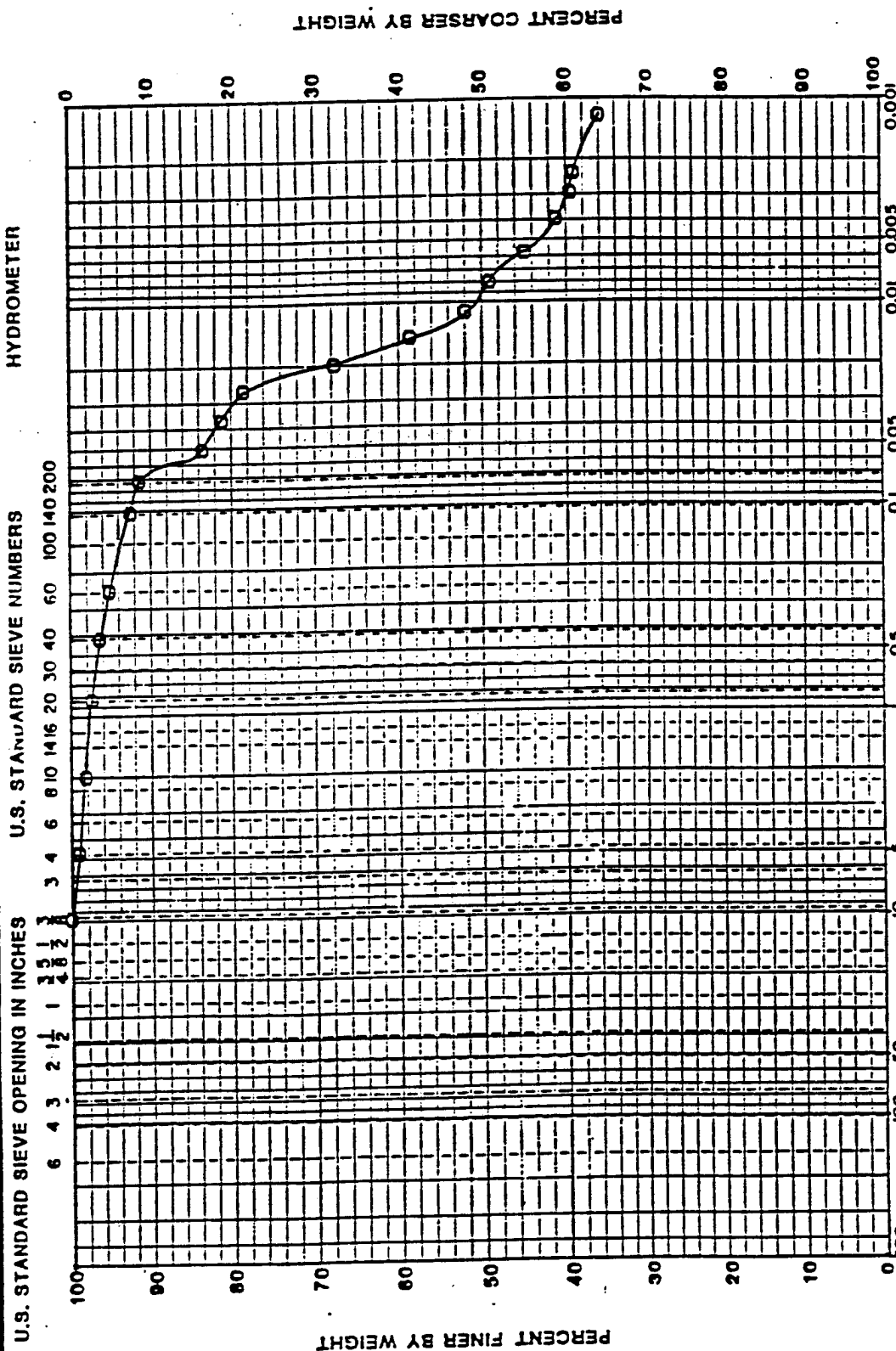
U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES

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GRADES

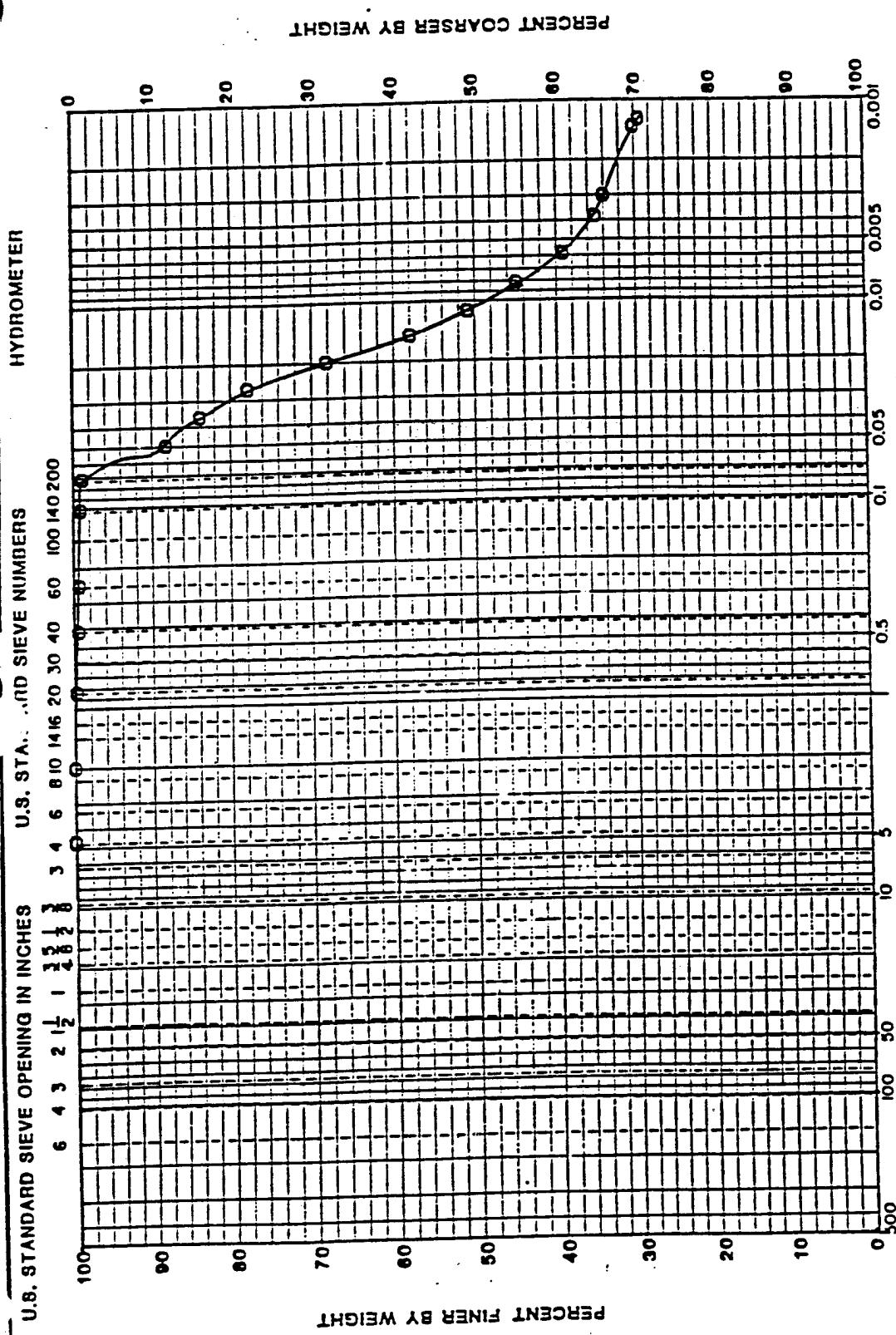


COBBLES		GRAVEL			SAND			SILT OR CLAY	
		COARSE	FINE		COARSE	MEDIUM	FINE		

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT. WT. %	LL	PL	PI	PROJECT
BULK	0.0-5.0	CH	5.4	53	18	35	WSSRP
							BORING NO. CTS-5
							DATE 11-8-89
							GEOTECHNOLOGY
							11295

52112

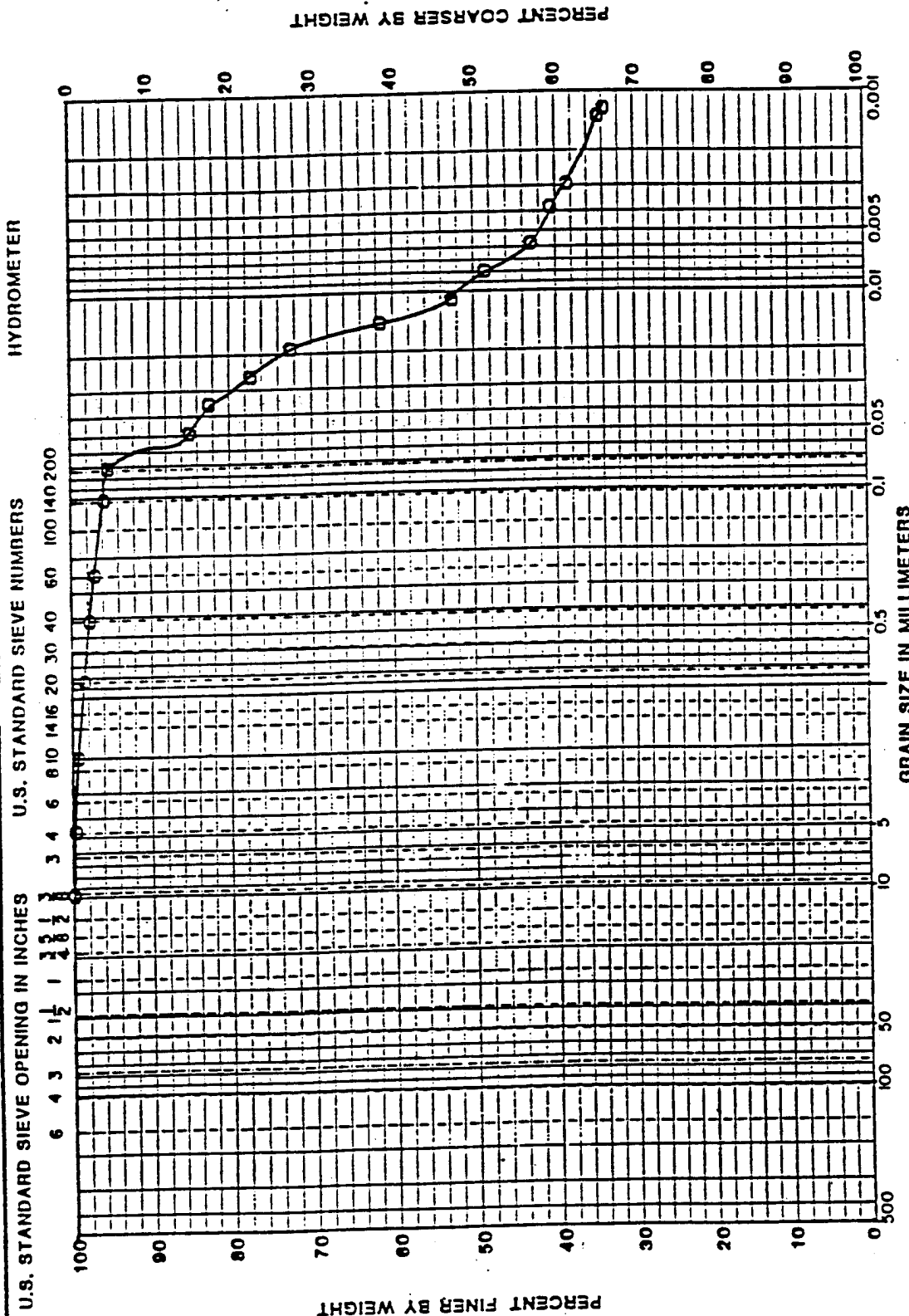
GRADATION CURVES



COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	FINE	COARSE	MEDIUM	FINE		

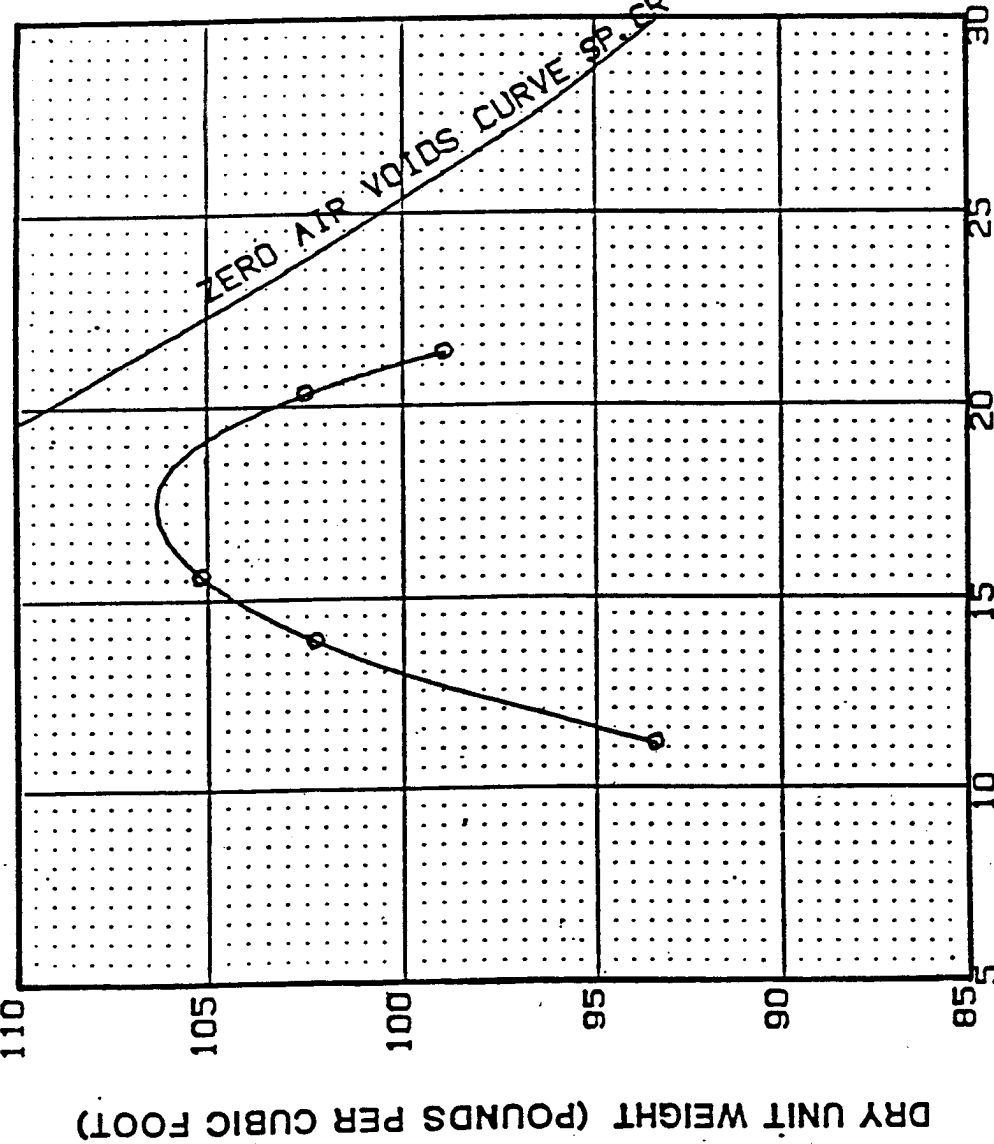
SAMPLE NO. BULK	EL. or DEPTH 0.0-5.0	CLASSIFICATION CL	NAT. WT. % 8.1	LL 43	PL 22	PI 21	PROJECT WSSRP
						BORING NO. GTS-8	
							DATE 11-8-89
							GEOTECHNOLOGY 1000 Lakeside Drive, Suite 100, San Francisco, CA 94134 Phone: (415) 774-1000

GRADES AND CURVES



Job # 11295

Date: 10-24-89



SPECIFICATIONS

STANDARD PROCTOR

ASTM D 1557-70, ASTM D 698-70

(Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
106.4	17.5	21.7

DESCRIPTION

Brown CLAY

ATTEBERG LIMITS

LL- 53 PL- 18 PI- 35

CLASSIFICATION SYSTEM

UNIFIED : CH

AASHTO :

SAMPLE INFORMATION

GTS - 5

0.0-2.0 FT

WSSRAP

WATER CONTENT (PERCENT)

COMPACTION TEST

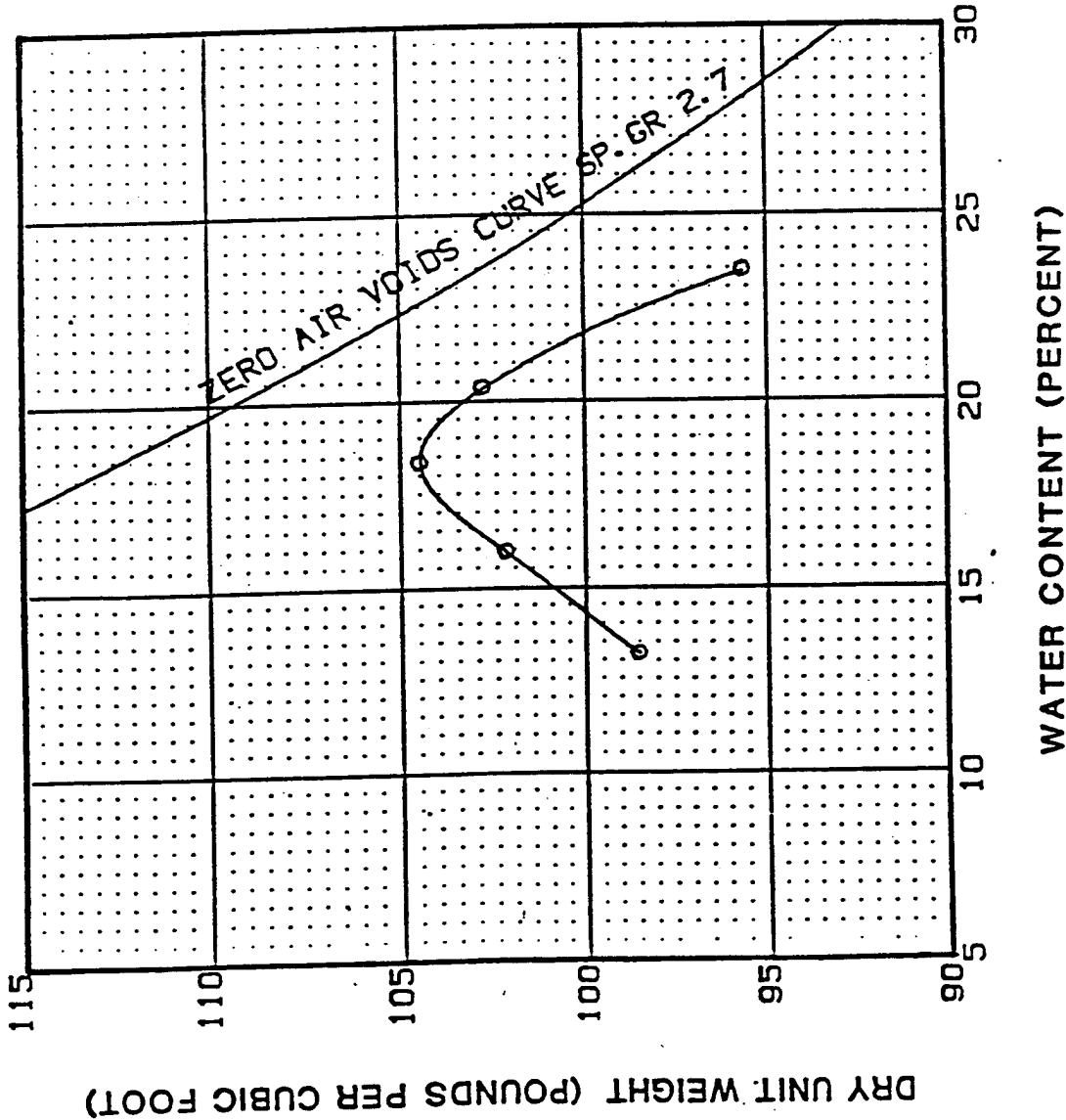


Checked by 77

PIATE

114

Job # 11295
Date: 10-18-89



SPECIFICATIONS

STANDARD PROCTOR
ASTM D 99-70, ASTM D 698-70

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
104.6	18.3	19.7

DESCRIPTION

Brown, silty CLAY

ATTERBERG LIMITS

LL- 43 PL-22 PI-21

CLASSIFICATION SYSTEM

UNIFIED: CL

AASHTO:

SAMPLE INFORMATION

GTS - 6 0.0-5.0 feet

WSSRAP

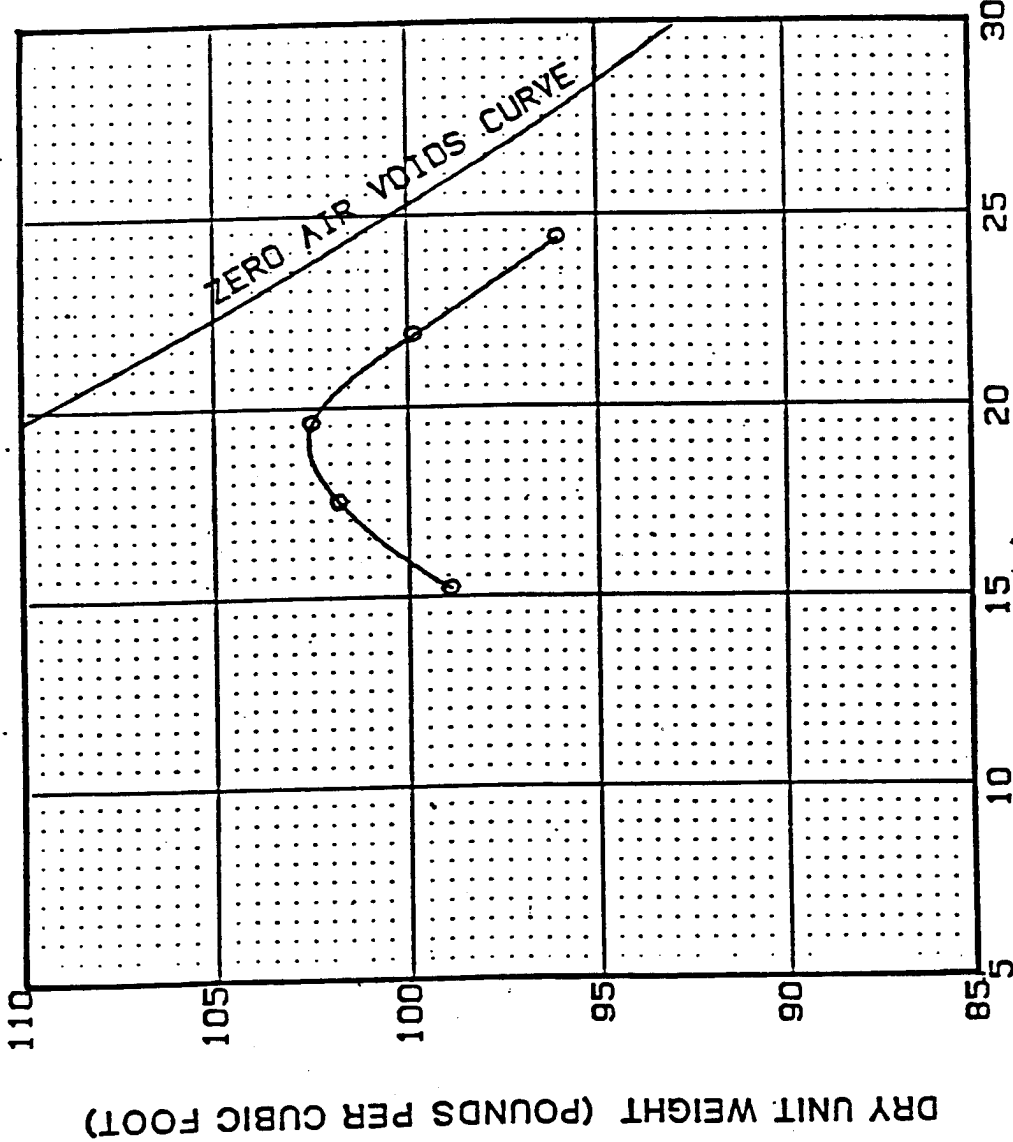
COMPACTION TEST



Checked by 77

Job # 11295

Date: 10-23-89



SPECIFICATIONS

STANDARD PROCTOR

ASTM T 99-70, ASTM D 698-70

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
102.7	19.2	23.8

DESCRIPTION

Iron Clay

ATTERBERG LIMITS

LL-59 PL-24 PI-35

CLASSIFICATION SYSTEM

UNIFIED : CI

AASHTO :

SAMPLE INFORMATION

GTS-7

0.0-5.0

WSSRAP

COMPACTION TEST



Checked by 77

102.8	17.5
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DESCRIPTION

Composite Brownish gray mottled, silty CLAY and gray, brownish yellow and brown CLAY

ATTERBERG LIMITS

LL- PL- PI-

CLASSIFICATION SYSTEM

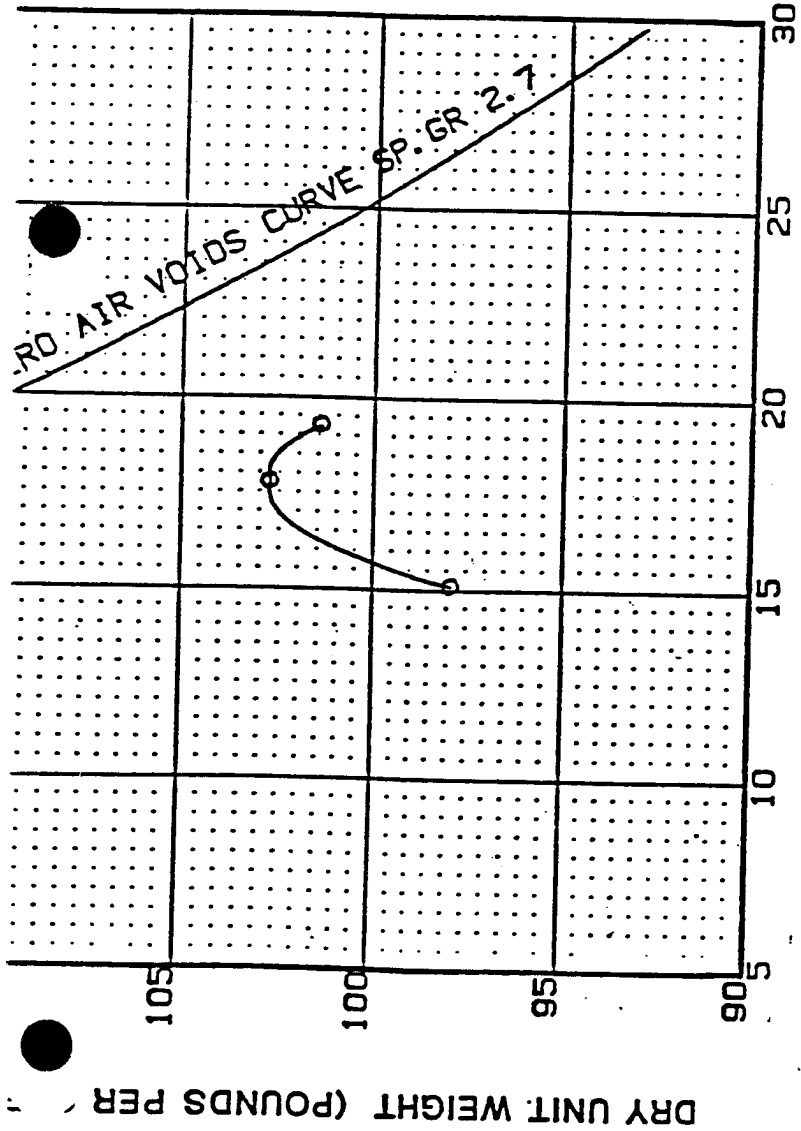
UNIFIED: CL and CH

AASHTO:

SAMPLE INFORMATION

GTS-1, STD3, 5-7.5 FT - LL-40, PL-20, PI-20 (CL)
GTS-3, STD2, 5-7.5 FT - LL-53, PL-18, PI-34 (CH)

WSSRAP



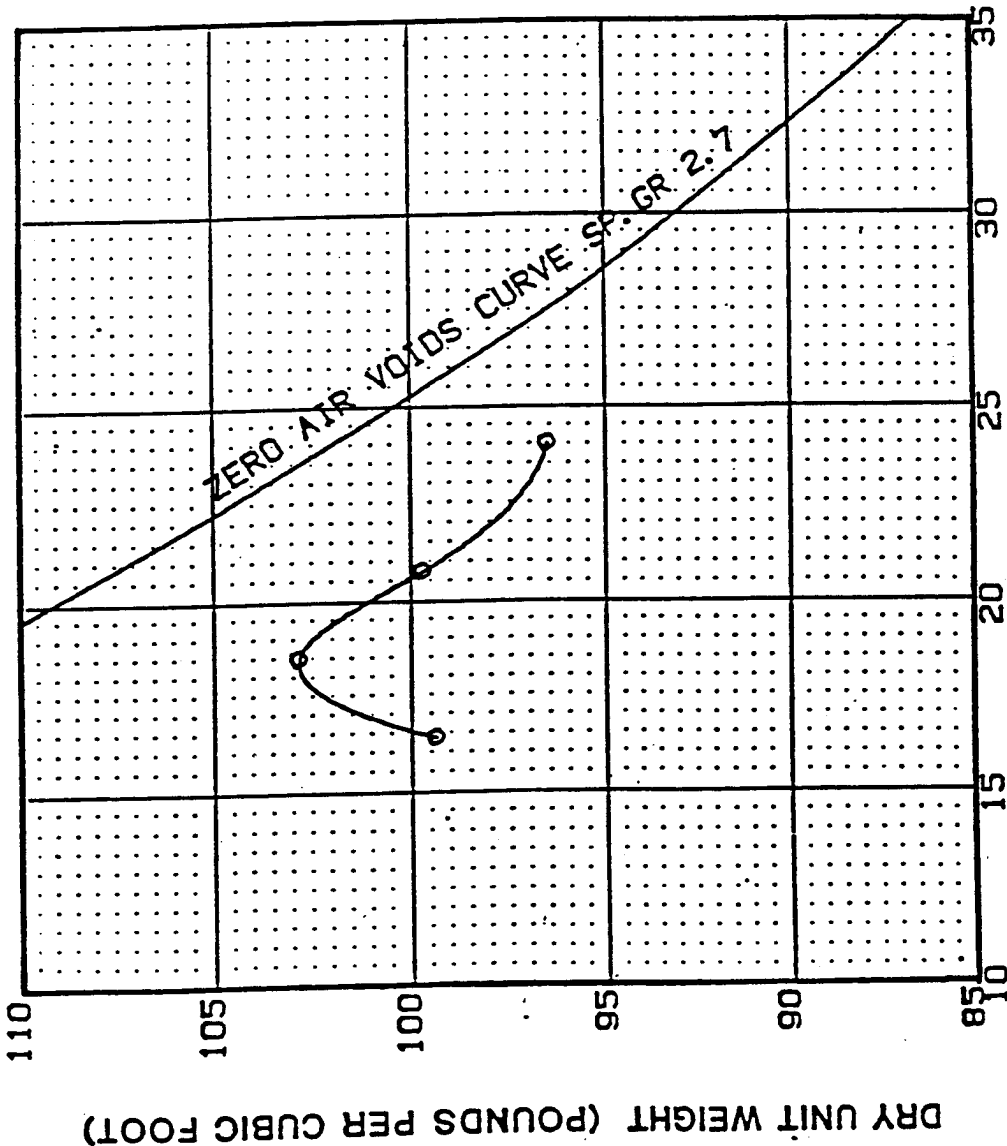
WATER CONTENT (PERCENT)

COMPACTION TEST



Checked by 47

Job # 11295
Date: 11-11-89



SPECIFICATIONS

STANDARD PROCTOR

ASTM T 99-70, ASTM D 698-70

Method A

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
103.0	18.3	

DESCRIPTION

Composite: Brownish gray, silty clay and brownish gray to grayish brown, clayey silt to silty clay

ATTERBERG LIMITS

LL- 44 PL- 20 PI- 24

CLASSIFICATION SYSTEM

UNIFIED : CL

AASHTO :

SAMPLE INFORMATION

GTS-2, ST02, 2.5- 5.0 FT

GTS-2, ST04, 7.5-10.0 FT

2.7

COLLECTION NAME

BY MKF SC 11/9/90

WSSRAP

WATER CONTENT (PERCENT)

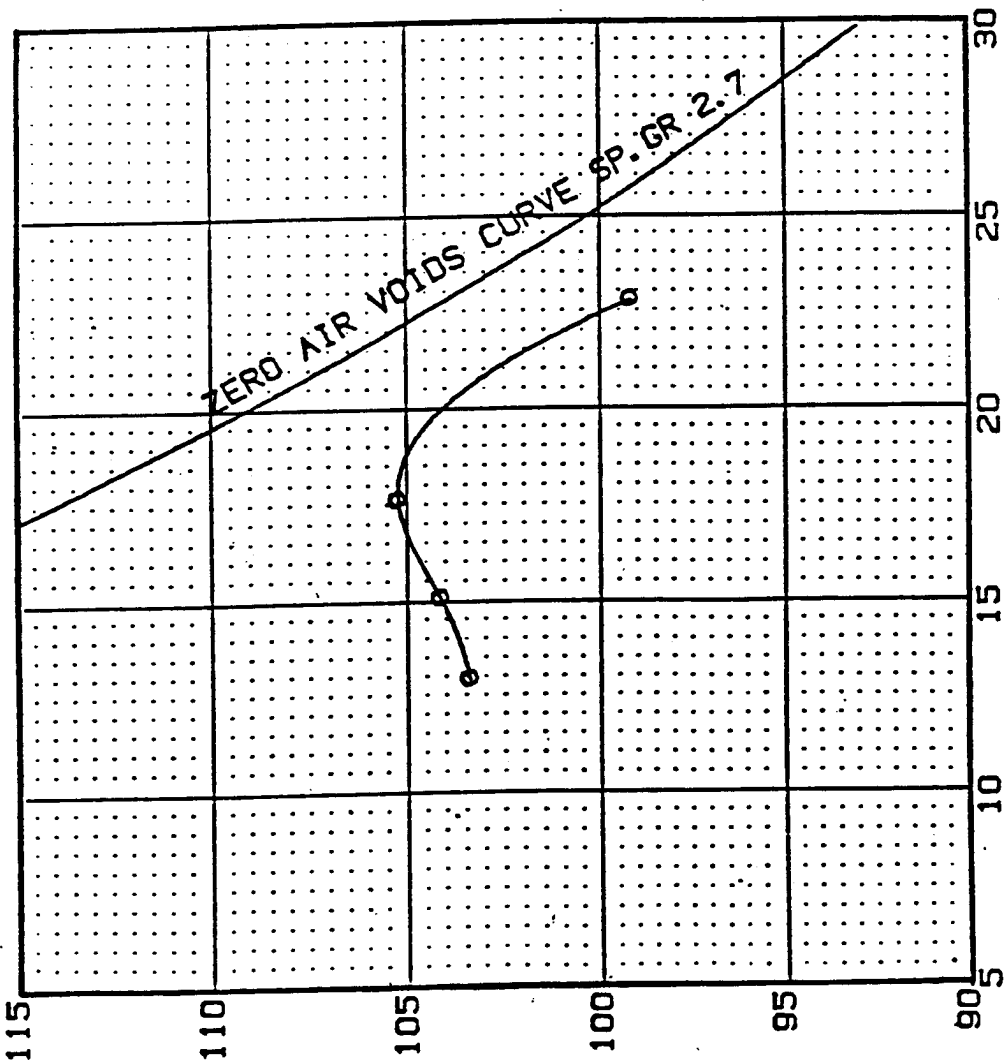
COMPACTION TEST



Checked by 47

Job # 11295

Date: 11-11-89



SPECIFICATIONS

STANDARD PROCTOR

ASTM D 698-70, ASTM D 698-70 (Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
105.3	17.7	

DESCRIPTION

Composite Dark gray to brownish gray silty CLAY to CLAY and grayish brown and gray mottled, silty CLAY

ATTERBERG LIMITS

LL- PL- PI-

CLASSIFICATION SYSTEM

UNIFIED :

AASHTO :

SAMPLE INFORMATION

GTS-4, ST02, 2.5- 5.0 FT - LL-51, PL-23, PI-28 (CD)
GTS-4, ST04, 7.5-10.0 FT - LL-41, PL-20, PI-21 (CL)

WSSRAP

WATER CONTENT (PERCENT)

COMPACTION TEST



Checked by 47



MK-FERGUSON

PERMEABILITY TEST RESULTS

BITE ID: WSS2A7

CHECKED BY: LAB 75

DATE: 6-6-90

TAC_____

LAB NAME: Geotech. no logy, inc

[illegible]

TEST ACTIONS:

CII - CONSTANT HEAD

FBI - FALLING HEAD

TX - MAXIAL.

SKI-RESUME FALLING HEAD

YES! PROCEED!

EM 1110-2-1906

A. assumed sp. Grunty

11/09/90